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ABSTRACT

This manual is designed to help instructors guide students through their manuals and laboratory training stations in the field of industrial electronics. The manual consists of the following nine sections: (1) suggestions for teaching the course; (2) an instructional delivery outline; (3) lists of essential elements common to all trade and industrial courses; (4) lists of essential elements for industrial electronics; (5) suggestions for adapting instruction for special needs students; (6) 29 references, including electronics books and manuals, personal development materials, audiovisual aids, and computer-assisted instructional materials; (7) answers to exercises that are contained in students' manuals; (8) answers to unit tests and final examination; and (9) unit tests and final examination. Table of contents for the student manual and a student record form are included. Topics covered in the course are as follows: review of AC and DC circuits and electronics basics, semiconductors, integrated circuits, digital logic, complex digital circuits, and computer circuits. A brief curriculum guide lists essential elements and specific objectives for each instructional unit. (KC)

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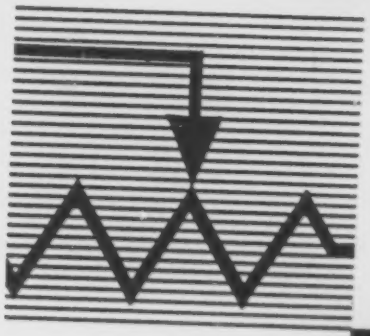

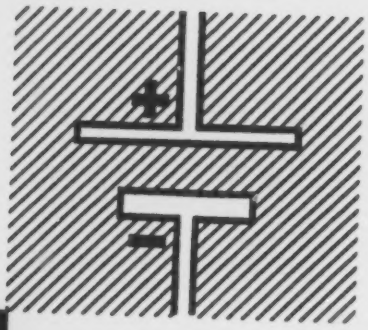

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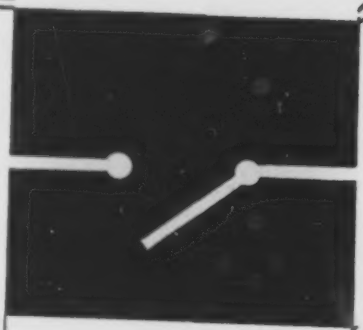

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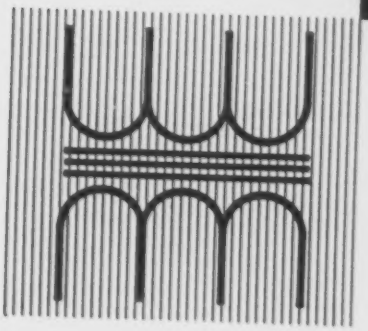

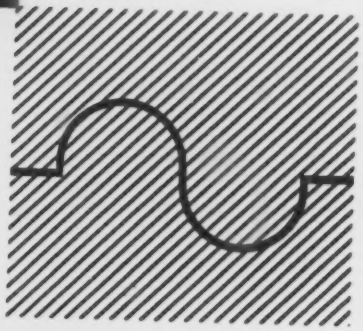

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Instructor's Guide

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INDUSTRIAL ELECTRONICS II for ICT

Instructor's Guide

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Published by

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Extension Instruction and Materials Center
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Preface

This material has been written to serve the needs of high school students who wish to continue their education in the field of electronics. The material was developed specifically for students who wish to learn industrial electronics. However, at this level, the course is broad enough to allow a student to enter any area of electronics.

In order to succeed in this field, students should have a good foundation in mathematics, chemistry, and physics. Good communication skills will also improve their chances of success.

Students will need a knowledge of algebra to understand and apply the material presented throughout this text. An understanding of physics and chemistry will help the students understand the internal structure of the components described in this text.

Acknowledgments

Sincere thanks and appreciation are extended to the following members of our advisory committee for their assistance in this project:

- Mr. Chris Brock, The University of Texas at Austin, Balcones Research Center, Applied Research Lab
- Mr. Doug Holberg, Consulting Engineer, has earned a special note of appreciation. His knowledge, dedication, and sense of humor improved the quality of the text, kept the project on schedule, and made the development of this curriculum enjoyable.

Notes to the Instructor

The instructor's guide is designed to help the instructor make certain that each student gets the most benefit possible out of both the student's manual and what is learned at the training station. It provides answers to exercises and unit test questions. It also provides a work sheet to help in coordinating work experiences with the assignments.

The instructor should keep all answers to questions. The actual tests can be removed from this book to make them easier to use or reproduce. For greater convenience, this guide is punched for notebook use and held together by staples only.

The student's self-contained manual is designed for use in presenting related technical information to (1) groups of trade and industrial students with a variety of vocational objectives and (2) homogeneous groups in which the learning levels of individuals vary considerably. The manual is not intended to be used as a type of correspondence course, but must be used by students under the direct supervision of an instructor.

Academic Background Recommended

The student must have the correct background in order to succeed in this field.

English. The student should have a good background in English and read at the eleventh-grade level in order to read and understand the schematics, specifications, etc.

Mathematics. The student should have a good background in math. Successful completion of one year of algebra is essential.

Science. Background courses in physics and chemistry are beneficial to the electronics technician.

Aptitudes. The student should have a high mechanical aptitude and a high degree of manual dexterity.

This information may be used in counseling students who express a desire to train in this field. It also could be useful to school counselors who may have the opportunity to guide students toward a vocational program.

Contents

A pretest/posttest is designed for each unit. It will give the instructor input concerning the student's knowledge of industrial electronics before the unit is studied and a method of measuring the amount of learning that resulted from studying the unit.

The student's manual is organized to guide the student through the linear section, which comprises Units A through C, and the nonlinear section, Units D through F. All assignments in these sections are basically designed so that the technical information can be studied in one hour.

The assignments are designed to require the student to use the information studied in the student's manual. Assignment exercises will require two to three class periods of one hour each to complete. An average of one reading assignment with the exercise should take three days of each week. It is suggested that the teacher-coordinator conduct group discussion the other two days.

Organization

The student's manual is designed to use as many fundamental teaching principles as possible. Each part of the manual is based on one of these principles.

Objectives. The first fundamental teaching principle is that the student should be *informed* at the outset the objectives to be learned in the assignment. These are performance objectives that can be tested on completion of the assignment.

Technical information. The second teaching principle is that technical information should be presented in *complete, but concise form.* This information is presented step-by-step,

proceeding from the simple to the complex, from the known to the unknown. Of the four teaching principles discussed here, this is by far the most important.

Exercise. The third teaching principle is that technical information is better learned if it can be *applied* as soon as possible after presentation. Application is done through exercise questions for each assignment. The questions are phrased to emphasize key points, to aid in learning facts that must be memorized, or to provoke thought about evaluation of the technical information. You should emphasize to students that both the objectives and the technical information should be read before any attempt is made to answer questions in the exercise. Answers may also be useful when helping a student who is having difficulty with an assignment exercise.

Tests. A fourth teaching principle is carried out in the instructor's guide. The principle is that the effectiveness of the assignments should be *evaluated*. Evaluation is effected through a unit test that is keyed to the objectives stated for the assignments. These tests should be given on completion of the unit. Answers to tests provide a reference for grading. *You should retain all answers.*

Tests and Work Sheet

The last section of this instructor's guide has been placed after a divider page so that the tests and work sheet can be removed for use with individual students or for reproduction. You can reproduce these pages *without permission.*

The work sheet is provided for your convenience in (1) planning how job experience is to be matched to related instruction in the student's manual and (2) keeping daily records as the student progresses through the year. The assignments are coded and can be easily listed opposite the desired jobs. Also, space is provided for other records you may wish to include on the work sheet.

Instructor's Guide and Student's Manual

The Instructor's Guide and the Student's Manual are available from:

The University of Texas at Austin
Extension Instruction and Materials Center
P.O. Box 7218
Austin, Texas 78713-7218

Instructional Delivery Outline

Assignment No.	Title	Essential Elements
A.	Introduction and Review	
A-1	Review of DC and AC Circuits	(o)(1,2,3,8,9,10,16)
B.	Semiconductors	
B-1	Diodes and Atomic Theory	(o)(5)
B-2	Rectifiers	(o)(4,5,9,11,15)
B-3	Filters and Zeners	(o)(4,6,7,9,11,15)
B-4	Diode Circuit LEDs	(o)(4,5,9,11)
B-5	Transistor Theory	(o)(5,11,15,16)
B-6	Transistor Switch	(o)(5,9,11,12,16)
B-7	Transistor Bias	(o)(5,6,9,11,12,16)
B-8	Transistor Amplifier	(o)(5,6,9,11,12,16)
B-9	Multistage Transistor Amplifiers	(o)(5,6,9,11,12,16)
B-10	Oscillators and Feedback	(o)(5,6,9,11,12,16)
B-11	Voltage Regulation	(o)(5,6,9,11,12,16)
B-12	Other Types of Transistors	(o)(5,6,9,11,12,16)
B-13	Thyristors	(o)(5,6,9,11,12,16)
C.	Integrated Circuits	
C-1	Op-Amp Theory	(o)(5,6,12,15,16)
C-2	Op-Amp Amplifiers I	(o)(5,6,12,15,16)
C-3	Op-Amp Amplifiers II	(o)(5,6,12,15,16)
C-4	Op-Amp Amplifiers III	(o)(5,6,12,15,16)
C-5	Nonlinear Op-Amp Circuits	(o)(5,6,15,16)
C-6	555 Integrated Circuit	(o)(5,6,9,11,15,16)
C-7	AM and FM Modulation	(o)(9,15,16)
C-8	Video Monitoring Systems	(o)(1,5,6,8,9,11,16)
D.	Digital Basics	
D-1	Introduction to Digital	(o)(4,15)
D-2	Binary, Hex, and Decimal Systems	(o)(13,16)
D-3	Logic Gates and Diagrams	(o)(13,16)
D-4	Boolean Algebra	(o)(13,16)
D-5	XOR and XNOR	(o)(13,16)
E.	Complex Digital Circuits	
E-1	Flip-Flops	(o)(13,16)
E-2	Registers I	(o)(13,14,15,16)
E-3	Binary Addition	(o)(13,14,15,16)
E-4	Decoders	(o)(13,14,15,16)
E-5	Encoders and Multiplexers	(o)(13,14,15,16)
E-6	One Shot and Schmitt Triggers	(o)(13,14,15,16)
E-7	Interface with the Linear World	(o)(13,14,15,16)
E-8	Data Transmission	

F. Computer Circuits

F-1	Memory Devices	(o)(13,14,15,16)
F-2	Microprocessor Theory	(o)(13,14,15,16)
F-3	Computer Language	(o)(13,14,15)

Essential Elements Common to All Trade and Industrial Courses

§75.88 Trade and Industrial Education

(a) The elements in this subsection are **common to all trade and industrial courses** unless otherwise indicated and shall be included in each course at the appropriate level. They are described here to preclude repetition in each course. Every school offering trade and industrial education shall provide courses which include the following essential elements:

(1) *Leadership* concepts and skills. The student shall be provided opportunities to:

(A) demonstrate skills, characteristics, and responsibilities of leaders and effective group members;
(B) demonstrate a knowledge of parliamentary procedure principles;
(C) plan and conduct leadership activities; and
(D) prepare for effective citizenship and for participation in our democratic society.

(2) Concepts and skills related to successful *employment* and/or *postsecondary training*. The student shall be provided opportunities to:

(A) identify employment opportunities and preparation requirements in chosen fields;
(B) identify effective methods to secure and terminate employment;
(C) demonstrate effective communication skills both oral and written and follow through on assigned tasks;
(D) demonstrate dependability and punctuality;
(E) demonstrate productive work habits and attitudes;
(F) understand the importance of taking pride in the quality of work performed;
(G) recognize the dignity in work;
(H) develop skills in planning and organizing work;
(I) apply required methods and sequences when performing tasks;
(J) apply principles of time management and work simplification when performing assigned tasks;
(K) identify ethical practices and responsibilities; and
(L) understand the importance of the application of organizational policies and procedures.

(3) Concepts and skills associated with *entrepreneurship*. The student shall be provided opportunities to:

(A) identify opportunities for business ownership;
(B) understand the risk and profit motive factor;
(C) understand the elements and advantages of the free enterprise system; and
(D) explain the role of small business in the free enterprise system.

(4) Concepts and skills related to *safety and safe working conditions*. The student shall be provided opportunities to identify and apply safe working practices to all training situations.

(5) Concepts and skills associated with *human relations and personality development*. The student shall be provided opportunities to:

(A) understand the importance of maintaining good health and proper appearance for effective job performance;
(B) understand oneself and others;
(C) exercise self-control;
(D) accept and use criticism;
(E) recognize basic human relationships as they relate to business success; and
(F) demonstrate characteristics for successful working relationships.

(6) Concepts and skills related to *personal and business management*. The student shall be provided opportunities to:

(A) explain how management assists in reaching personal and family goals;
(B) explain the management process;
(C) describe the role of management in controlling stress;
(D) identify and understand personal checking accounts;
(E) identify and understand personal loan application process;
(F) identify and understand different financial institutions;
(G) identify the role and function of business management;
(H) understand the lines of authority; and
(I) identify effective supervisory techniques.

(7) Concepts and skills associated with the *specific occupation* being taught. The student shall be provided opportunities to:

(A) understand the basic concepts of and develop proficiency in the occupational area for which instruction/training is provided;
(B) develop a fundamental understanding of mathematical principles and scientific procedures;
(C) understand terminology utilized;
(D) identify tools, equipment, and materials used; and
(E) develop and demonstrate appropriate techniques for the selection, use, maintenance, and storage of tools, equipment, and materials.

(o) Concepts and skills associated with *industrial electronics*. The student shall be provided opportunities to:

(1) apply Ohm's law and power theory;
(2) investigate direct current circuit analysis;
(3) understand magnetism as it relates to electronic circuits;
(4) design and build electronic circuits utilizing schematic diagrams;
(5) understand the structure, theory, and operation of semiconductors and integrated circuits;
(6) apply a method of testing semiconductor devices using *appropriate* test equipment;
(7) investigate voltage regulation devices;
(8) understand the relationship of voltage, current, resistance, and reactance in alternating current circuits;
(9) understand electronic theory and application as it applies to generators, electric motors, power supplies, electronic amplifiers, electronic oscillators, communication circuits, and communication systems;
(10) investigate AC circuit analysis;
(11) analyze malfunctions in electronic circuitry;
(12) understand the operation of basic transistor circuits and operational amplifiers in linear circuits;
(13) analyze digital electronic circuits;
(14) investigate microprocessor applications;
(15) become aware of state of the art technology; and
(16) apply the proper procedures for the use of electronic test equipment.

Adapting Instruction for Special Needs Students

The primary purpose of this unit is to provide the vocational educator with teaching strategies and techniques that will be useful when instructing students with special needs. It is important to remember that the methods and approaches used by educators when instructing non-special needs students may not be very effective with students with special needs. Therefore, **individualizing** instruction becomes vitally important in the successful instruction of special learners.

LEARNING STYLES

Each special learner has unique needs and these needs affect how the student can best learn. For example, if a student is blind or has difficulty with "visual" learning, the instructor should stress the learner's sense of hearing and touch. If the student is deaf, the instructor should involve the learner's sense of sight. Therefore, the manner in which a student with special needs learns ceases to be a preference, but becomes instead a **necessity**. Further, one of the main philosophies behind individual learning styles is that learning should be a pleasant and successful experience. Educators, therefore, should adjust their style of teaching to allow students the benefit of learning in their preferred manner.

The following are methods an educator can use to identify a student's learning style:

1. **Informal observation.** One of the simplest and possibly best ways to identify a student's learning style is through informal observation. By observing the student as he or she negotiates classroom/laboratory learning activities, the educator can collect valuable information with regard to the student's learning style. For example, the educator may observe that a disadvantaged student answers questions in class and does well with hands-on activities but repeatedly fails written exams. If the primary intent of the instruction is to teach vocational skills rather than reading and writing skills, the instructors could modify their style of teaching by allowing the student to take oral and/or hands-on exams.
2. **Teacher consultation.** Consulting other teachers (i.e., special education teachers, resource room teachers, support personnel, paraprofessionals, and other vocational education teachers) can be an excellent source for information regarding a student's learning style.
3. **Student/parent interviews.** Interviewing the student and student's parents/guardians can result in valuable insights as to the student's best learning modes.
4. **Standardized inventories.** Standardized inventories provide an alternative for students who are shy or uncomfortable during a personal interview. Information received from interest, personality, and learning style inventories can provide valuable information with regard to the student's learning style.

INSTRUCTIONAL STRATEGIES

Once the student's vocational goals, learning capability, and preferred learning style have been identified, the educator can begin to experiment with a **variety** of teaching techniques and instructional materials. When determining the teaching technique and instructional material best suited to meet a student's unique needs, it is important for the educator to be patient, open-minded, and flexible. Not every instructional technique and/or material can be used successfully with each learner. In addition, the educator should not hesitate to enlist the support of other instructors, school counselors, student aides, paraprofessionals, volunteers from the community, itinerant

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Note: Adapted from the *Vocational Special Needs Teacher Training Curriculum*, developed at Texas A & M University and available through the Extension Instruction and Materials Center, The University of Texas at Austin. See that publication for additional information and references on special needs students in vocational classrooms.

teachers, and/or interpreters. This pooling of efforts can result in increased student learning because of the variety of approaches and personal attention which can be brought to the classroom or laboratory.

GENERAL GUIDELINES AND INSTRUCTIONAL STRATEGIES

The following are general guidelines and instructional techniques which an educator can use to help meet a special needs learner's unique needs and learning style:

1. **Orientation.** Students with special needs may need additional orientation with regard to: (a) the relevancy of their individualized goals, (b) class procedures, (c) safety, etc.

2. **Flexible pacing.** Students with special needs can exhibit different rates of learning. The educator should provide flexibility in pacing of instruction and assignments to meet the various needs of learners. In general, students with special needs should be individually paced to maintain their progress and interest, yet avoid the frustrations and failure undue pressure may cause.

3. **Demonstration.** Utilization of the demonstration method can be very effective in introducing a new skill to a learner with special needs.

4. **Breaking material into small distinct steps.** As a general rule, it is important for the educator to break a learning concept into small distinct steps. In this way, the educator can best identify where the student is experiencing difficulty.

5. **Positive environment and feedback.** In general, students with special needs lack confidence and a positive self-concept. This is primarily due to their not having had much success in life. In addition, the few successes special learners do have usually result in little, if any, positive reinforcement (i.e., praise, reward, and/or encouragement). Therefore, it is incumbent upon educators to create a positive, nonthreatening learning—environment for their students and to make generous use of positive feedback when the student experiences success. Constructive criticism **should not** be avoided; however, it should be given in a positive manner (i.e., students should understand that their behavior or product is what's being criticized and **not** their worth as a human being). Finally, all students must learn that mistakes and constructive criticism are a normal and expected part of life.

6. **Use of peer tutors, college students, and volunteers.** Use of peer tutors, college students, and volunteers can greatly assist a vocational educator's work with special learners by: (a) helping with individualized instruction, (b) providing positive role models, (c) increasing student participation, (d) increasing the special learner's success experiences, (e) increasing the student's confidence and self-esteem, and (f) improving the special learner's social and academic skills. In addition, peer tutors, college students, and volunteers can receive teaching experience and the satisfaction of helping individuals with special needs progress.

7. **Flexible grouping.** The educator can integrate special needs learners into groups of various sizes (according to the student's goals, interests, or ability level) and utilize peer tutors, college students, and volunteers for assistance. Grouping students has the following advantages: (a) it allows the teacher more time to work among the students, (b) it allows the teacher to individualize instruction, tasks, and assignments to meet the needs of students in a specific group, (c) it provides special needs learners with an opportunity to work with peers and establish positive interpersonal and working relationships with them, (d) it serves as a motivating factor for special needs learners because the individualized nature of the group work does not become threatening or frustrating but allows students an opportunity to work at their own pace through their strongest learning style, (e) it allows teachers to arrange for instruction for the entire class, small group discussions, project groups, and small remedial sessions so that instruction will be diversified and more meaningful for all students; and (f) it allows the teacher to modify the task or assignment for a small group of students with specific needs, as in the case of learners who have a physical disability.

8. **Providing field trips and job site visits.** Scheduled field trips and job site visits can give all learners a realistic firsthand look into the real world of work. By "shadowing" workers in a particular occupational area, students can gain helpful insights into their own career

decision. In addition, a field trip or job site visit can be very motivational in that the student can readily observe how his/her vocational training will be used in the world of work.

9. **Use of media.** Utilizing media can embellish instruction by: (a) assisting the teacher in presenting the proficiency or skill requirements for a specific job, (b) reinforcing concepts presented in a classroom, laboratory, or demonstration activity, (c) providing a vehicle for special needs learners to show what they have learned, (d) providing a valuable source of remedial assistance, (e) providing simulated learning experiences, (g) allowing special needs students to learn through their strongest style, and (h) adding variety to the instructional program. Examples of media include: computer-assisted instruction (CAI), 16mm films, filmstrips, flip charts, overhead transparencies, tape recorders, records, posters, magazines, and diagrams.

10. **Use of student-teacher contracts.** Student-teacher contracts can be excellent tools in helping learners with special needs achieve their vocational goals. The following guidelines should be used in developing and implementing a student-teacher contract: (a) decide on the task or project, (b) specifically state the requirements, (c) determine the minimum acceptable accuracy, (d) set a time limit—initially, short assignments and short time periods are usually best, (e) identify consequences, (f) discuss contract with student and support personnel, (g) have all parties sign the contract, (h) positive reinforcement should be given if the terms of the contract are satisfactorily met, (i) uncompleted contracts should be analyzed by the teacher and student to determine the causes, and (j) develop new contracts cooperatively.

SPECIFIC GUIDELINES AND INSTRUCTIONAL STRATEGIES

The following is a list of specific teaching strategies which educators can utilize when addressing the unique needs of special needs students. It is very important to note that many of these teaching strategies should be used for all students.

Instructing Students Who Are Mentally-Impaired

- Involve as many different senses as possible in the learning process.
- Use concrete specific terms rather than abstract terms. If necessary, have the student repeat the necessary information to you.
- When giving written directions use lists instead of paragraphs. With regard to the student who can barely read, contact the remedial reading staff and arrange reading instruction. This instruction should focus on required reading for your course and that which is vital for employment.
- Teach by demonstration (whenever possible). Don't hesitate to use hand-over-hand assistance in demonstrating how to use a tool or machine.
- Allow time to practice machine or tool processes.
- Break down complex operations into smaller tasks.
- With regard to feedback, let the learner know what is wanted, and whether or not the student is achieving it. Give lots of positive reinforcement and encouragement. Nonverbal feedback is also helpful (i.e., touching the student or task, pointing, blocking or stopping an error as it is developing, and guiding the learner's movements). In addition, provide specific feedback with regard to the student's work. For example, the educator should say, "This piece was cut exactly to the right size," or "You put these two parts together correctly," or "Try another way."
- Build the student's confidence by: (a) utilizing activities that will assure success, (b) assigning special tasks which will communicate with the educator's confidence in the student, (c) giving students an opportunity to correct their work and hand in a good project or assignment, and (d) displaying the student's good work.
- In helping students with their ability to make correct discriminations, utilize the "match to sample" technique in which the student is provided an example and a number of choices. The student will choose the correct alternative based upon the characteristics of the sample.

- With regard to helping the student make correct discriminations when there are **minimal** differences between the stimuli, it may be necessary to: (a) present the choices in an easy form at first, (b) exaggerate attributes, (c) make the choices gradually harder, or (d) add and then fade out color cue, add and then gradually remove large cue differences, or
- Retention/memory can be improved by: (a) being systematic and presenting one new piece of learning at a time, (b) relating new material to familiar material, and keeping it practical and concrete, and (c) utilizing training techniques such as the total task method, chaining, modeling/demonstrating, and the structured overview.
- "Generalizing," or having the student apply what has been learned to the contexts, can be improved by: (a) using examples from different relevant contexts and (b) practicing in settings similar to or exactly like those that will be encountered on the job.

Instructing Students Who Are Hearing-Impaired

- In private, discuss with the student his/her ability to communicate with you (lip/speech reading, use of hearing aid, writing, signing, and total communication). An open discussion with the student which demonstrates your concern as an educator is an excellent beginning in building rapport.
- Body language communicates message too. Remember not to give mixed messages with your body language. Also, be alert to the body message the student is giving you (i.e., is he/she communicating tension, nervousness, avoidance, or confusion?)
- If you will be working with an interpreter, do not instruct the deaf student as if he/she were a third party. Speak directly to the student. Also, remember that the interpreter is ethically bound to interpret everything you say. Therefore, sensitive or other issues concerning the student is best addressed in a meeting before or after class. If you are using media where the room must be darkened, focus a small lamp on the interpreter.
- Maintain good eye contact with the student while speaking.
- Speak slowly and clearly, pronouncing each word, but without exaggerating or over pronouncing.
- Do not stand in front of a window while speaking. The light should be shining on your face and not the student's.
- Try to rephrase a thought rather than saying the same words over again.
- Encourage the student to read ahead on class material.
- Try to keep the noise level down as much as possible in the class/laboratory.
- Utilize handouts, the chalkboard, and other media.
- Install a light to indicate when dangerous machinery is on.

Instructing Students Who Are Speech-Impaired

- Always maintain eye contact and nod your head while the student is talking. This will help the student build confidence.
- Work cooperatively with speech therapist and/or communication specialist to determine which technique will help most in assisting these students to communicate more effectively.
- Encourage peer tutoring and small group activities to help the speech-impaired student develop interpersonal relationships with the other students.
- Always allow sufficient time for the student to complete his/her sentence.
- Try not to act uncomfortable when these individuals are communicating with you (i.e., discontinuing eye contact, shifting your position, clearing your throat). Your discomfort can be very discouraging to the student.
- Do not require these individuals to present oral reports until they feel comfortable in the classroom environment.
- Model correct sentence structure for the speech-impaired student so he/she can follow your example.

- Develop a list of technical terms used in your class and share these terms with the speech specialist to help the student become more confident in pronouncing terms used in class.

Instructing Students Who Are Visually-Impaired

- Orient the student to the classroom or laboratory before the course begins. Consistency and orderliness in the physical environment is very important to the visually-impaired student.
- Arrange seating so the blind student will be able to hear the instruction and to allow for the best distance and lighting conditions for the partially sighted student.
- Provide as many opportunities as possible for the visually impaired student to observe closely or to touch the materials.
- Give materials and handouts to the student ahead of time. Also, a student peer can assist the visually-impaired student by making a carbon copy or a photocopy of their notes. Also, when possible, the educator can make a copy of their teaching notes. In this way the visually-impaired student can review the materials with a tutor or have them transcribed into
- It is important to gain and maintain the student's attention. Approval or disapproval will need to be verbalized.
- Remember there is no need to talk louder to a visually-impaired student.
- Rehabilitation counselors or special needs teachers can be useful resources in helping the student use commercial or modified learning aids or tools.
- Tests may need to be prepared in large print, braille, on cassette tapes, or converted into exercises using the sense of touch. Also, it may be necessary to allow the student extra time to complete the test.
- The tape recorder is the most frequently used technique for notetaking and preparing modified learning materials for the visually-impaired student.
- The following is a sample of specially designed machines now available for the visually-impaired student: (a) OPTACON (Optical to Tactile Converter) allows students to read printed material, (b) STEREO-TONER is similar to the OPTACON but converts the printed word into a tone pattern, (c) OPTOPHONE and VISOTACTOR convert print into sound, and (d) KURZWEIL READING MACHINE which converts standard English text on a computer into easily comprehended speech.
- A number of general tools or aids which can assist the student in reading or writing lessons for vocational courses follow: (a) braille, (b) large print, (c) tape recorders, (d) talking books, (e) raised letters, (f) slate and stylus (used to make notes), (g) braille writer (a 6-key manually operated machine), (h) typewriters, (i) braille verifier (types braille and regular copy simultaneously), and (j) signature guides.
- Aids for mathematics and computer programming courses follow: (a) abacus designed for the blind, (b) raised clock faces, (c) wire geometrical forms, (d) braille rulers, (e) raised-line checkbooks, (f) raised-line boards, (g) braille dominoes, (h) braille flash cards, (i) cubes with raised braille dots used for simple mathematical problems, (j) raised-line paper or graphs, (k) computer terminals that use braille printers, or those that type braille and conventional type simultaneously, and (l) talking calculators.
- Aids used frequently in other vocational courses include: (a) braille maps, charts, diagrams, (b) self-threading needles, (c) wooden or cardboard models of specimens that other students see through microscopes, (d) braille micrometers and other shop tools that have special raised markings, (e) braille demo tapes to mark lab equipment and models, (f) light probes with audible sounds that check the operating status of machines, and (g) guides or templates to help students align objects properly.

Instructing Students Who Are Seriously Emotionally Disturbed

- Consult with the student's parents, special education teacher, or counselor to determine whether any particular teaching techniques will help or hinder learning.

- Try to understand the student. Disturbing behaviors are the outward sign of inner turmoil.
- Go easy on bad days and avoid direct confrontations that would aggravate the situation.
- Communicate acceptance to the student and a willingness to help him or her succeed in class.
- Provide immediate feedback and reinforcement.
- Establishing a rapport and trust with the student is important.
- In the beginning of the semester, help the student gain confidence by giving him or her lessons in which success can be achieved in a series of small steps.
- A measure of privacy when the student attempts a new task can ease his or her embarrassment at any awkwardness or ineptness.
- Allow the student to correct mistakes prior to turning in an assignment or project to ease any pressure.
- Help the student not to overreact to failure and praise him or her for continuing to try.
- Cue appropriate behavior in a quiet, unemotional manner.
- In resolving discipline problems: (a) do so in privacy, (b) focus on objective facts in a calm, supportive tone, (c) actively listen to the student, (d) after listening to the student, reflect on what has been said, by telling the student what you've heard, (e) ask the student if he or she has any ideas about solving the problem (encourage the student to be specific), and (f) conclude with a clear understanding of the changes, time-frame, and benefits which
- In handling aggressive behavior: (a) try to remain calm and model the controlled behavior which you desire, (b) intervene by either separating the individuals involved and having them work on another activity or having them take a time-out in separate corners of the room, (c) if necessary, send an uninvolved student to the office to get help, either in talking to the students or in managing the class while the teacher talks to them, and (d) return to normal classroom procedure as quickly as possible.
- Access professional colleagues in special education evaluation, counselling, or therapy when the student's behavior appears to be in need of additional attention.

Instructing Students Who Are Orthopedically-Impaired

- In general, students with physical handicaps will be intellectually capable and able to participate in vocational programs.
- Make the necessary modifications in classrooms, laboratories, equipment, building accessibility, and lavatories.
- For notetaking the student can: (a) use a tape recorder, (b) have a classmate slip a carbon copy into his/her notebook to duplicate notes, and/or (c) have the instructor prepare an outline of the lecture.
- For exams the instructor can: (a) give oral exams, (b) have the student dictate answers into a tape recorder or to another student, or (c) utilize a typewriter/computer if the student is able to type/keyboard.
- Give the student more time to complete homework assignments. Also, giving the student advance notification of assignments is helpful.
- In the laboratory, pair the student with one or more capable students in the class.
- Enlarged copies of frequently used charts and diagrams posted near the student's desk eliminates the necessity of paging through a book.

Instructing Students Who Are Other Health-Impaired

- Allow the student sufficient time for rest.
- Seat the student in the most convenient place for easy access to necessary facilities (hall, lavatory, chalkboard, laboratory work stations).
- Allow the student to work on program requirements at his or her own pace.
- Tape lectures so the student can listen to them at home.

- Work cooperatively with the health team in order to learn more about the student's special needs.
- Utilize community resource personnel (social workers and itinerant teachers for home-bound students) for delivery of materials, assignments, and handouts.

Instructing Students Who Have Specific Learning Disabilities

- Use visuals and demonstrations as often as possible.
- Use concrete examples whenever possible.
- Provide student with an outline of what will be covered in class.
- Make sure all printed materials are clear and readable.
- If the student has a visual perception problem, allow him or her to tape-record assignments.
- Allow students to take tests orally or in a mode that complements their performance.
- Present new information in small amounts.
- Make sure that writing assignments are relevant to the content of the program.
- Allow students a longer period of time to complete assignments, if necessary.
- List assignments in steps.
- Task analysis can be used to lower the frustration level of these learners.
- Programmed instruction materials can be very effective with these learners.

Instructing Students with Limited English Proficiency (LEP)

- Recognize the student's cultural background and allow for the student's individual differences.
- Encourage these students to bring dictionaries to class.
- Use demonstrations and hands-on experience as much as possible.
- Speak slowly and use simple vocabulary and grammar.
- Use bright felt-tip markers to mark important words, passages, or illustrations.
- If possible, use a translator for important concepts.
- Work closely with LEP support personnel.
- Keep homework assignments short.
- Check for comprehension by asking the student what you have said.
- Use simple sentences when writing test items so the student can concentrate on answering the question rather than deciphering it.

Instructing Disadvantaged Students

With regard to the disadvantaged population, typically these individuals dislike school, lack motivation, and have a low self-concept or esteem. Therefore, an educator's personal commitment and high expectations for the student may be two of the biggest single factors which will make a positive difference in this individual's life. Additionally, an educator's good example (i.e., being patient, understanding, well organized, and a good manager) can be extremely valuable in motivating and positively shaping the student's behavior. Vocational education can offer opportunities to the disadvantaged student in terms of teaching academic and social skills relative to the student's potential employment. The following are additional techniques or teaching strategies which can be very useful when working with disadvantaged students.

- The educator should seek to understand the student's educational and social background through: (a) assessment information, (b) interaction with former teachers, (c) discussions with counselors, and (d) visits with parents to ascertain the student's social limitations and home situation.
- Basic math, communication, and social skills should be reinforced. Math skills can be reinforced through hands-on learning activities. Communication skills can be improved by tactfully correcting poor grammar, when appropriate, and by providing resources that

encourage reading in job related interests. Social skills such as getting along with people, grooming, proper dress, and respect for property and authority should be reinforced on a continual basis.

- The importance of finishing school should be continually stressed. Relate acquisition of job skills to earn income.
- Reinforce the student's feelings of self-worth by having high expectations for the student and by providing immediate reinforcement for work done well.
- Simulate realistic job situations. All classroom and laboratory experiences should relate to employment in the occupation being studied.
- Disadvantaged students (as all students) will typically react to the learning environment in a responsible and mature manner when they are treated with respect and as adults by the
- Classroom organization and discipline (being firm but not overbearing) are especially important. Generally, disadvantaged students want and need structure and discipline within their lives. Usually, these individuals will be responsive to and respect teachers who are firm, but sensitive.
- Help the student develop employability and job coping skills (i.e., skills associated with finding, applying for, and retaining a job).
- Help the student establish good work habits by keeping him or her involved with meaningful learning experiences. Each activity should have concrete learning objectives.
- Disadvantaged students may need more encouragement to stay on task; however, they still should be required to complete all assignments (just as they will be required to do on the
- Present instructions and information in clear, logical steps—building from the simple to the complex.
- Technical terms should be communicated clearly and concisely and written in language which the students will understand.
- Incorporate a variety of instructional methods in the curriculum (i.e. demonstrations, resource personnel, field trips, peer tutors, role playing, audiovisual aids, and on-site work experiences).
- Present supplemental material when appropriate. If such material is relevant to the acquisition of job skills, the student will not be humiliated by simplified material.
- Highlight important parts of the student's text with a light marker to prevent the student from feeling overwhelmed with a large volume of reading material.
- Progress charts can be utilized to motivate disadvantaged students to master new skills.
- Utilize flash cards (teacher-made or commercial) to reinforce new terms and the use of tools and equipment.

GENERIC GUIDELINES AND INSTRUCTIONAL STRATEGIES

When teaching special needs students, it is very important that instructors do not limit their instructional techniques. Therefore, the following abstract of instructional techniques or strategies has been prepared which could be considered generic to all special needs populations.

- Involve as many different senses as possible
- Use concrete terms
- Have students repeat important information
- Use lists rather than paragraphs for written directions
- Teach by demonstration
- Use hand-over-hand assistance when necessary
- Allow practice time
- Break complex operations into smaller tasks
- Provide immediate feedback
- Build confidence
- Help student make correct discriminations

- Help student with their retention/memory
- Help student generalize knowledge
- Build rapport
- Use appropriate body language
- Use appropriate techniques when working with an interpreter
- Maintain good eye contact
- Speak slowly and clearly
- Rephrase thoughts when necessary
- Encourage the student to read ahead
- Keep the noise level down
- Utilize various forms of media
- Use lights to indicate when dangerous machinery is on
- Work cooperatively with therapists
- Encourage peer tutoring
- Try not to act uncomfortable around special needs students
- Help students feel comfortable
- Model correct sentence structure
- Develop a list of technical terms for students and/or therapists

- Orient students before the course begins
- Provide handouts ahead of time
- Maintain student's attention
- Use tape recorders for note taking
- Try to understand the student
- Communicate acceptance
- Develop success experiences for the student

- Use appropriate behavioral management techniques
- Facilitate the students with their notetaking
- Facilitate the students with exams

- Pair students
- Enlarge charts and diagrams
- Use clear readable visuals frequently
- Provide an outline of material which is being taught

- Writing assignments should be relevant
- Use task analysis when necessary
- Allow for individual differences
- Encourage students to bring a dictionary
- Use felt tip marker to highlight important parts
- Do not make homework assignments too lengthy
- Use simple sentences when writing test items

- Simulate realistic job situations
- Treat all students with respect and dignity
- Provide structure and organization
- Utilize progress charts
- Utilize flash cards

BASIC SKILLS REMEDIATION

It is very important to note that some students may need to acquire one or more basic education skills (i.e., mathematics, reading, writing, speaking, listening, interpersonal relations, and/or

reasoning skills) to succeed in a vocational program. In addition, many employers will not hire an individual if he or she lacks these skills. Therefore, instruction in basic education skills may be necessary.

MODIFICATION OF THE CURRICULUM

PURPOSE OF CURRICULUM MODIFICATION

When working with students with special needs, a learner's curriculum may need to be modified or adjusted to take into account major differences which could be found among these individuals. The term "curriculum modification" can be defined as tailoring an existing curriculum to the unique needs of students as they pursue an occupational goal. However, it should be strongly emphasized that modifying a curriculum **does not** mean that an educator should lower or alter the standards of his or her program. What it **does** mean is that the Admission Review and Dismissal (ARD) Committee (for handicapped students) or coordinated planning team (for disadvantaged and LEP students) determines which essential elements in the regular school curriculum would be appropriate for a student's needs. The *State Board of Education Rules for Curriculum* offers the following key points (Texas Education Agency, 1985).

1. For students with special needs, school districts shall provide modifications in methodologies, pacing, and materials to ensure that instruction is delivered, as appropriate, in the essential elements.
2. Students with special needs shall be instructed in those same essential elements in a manner appropriate to their needs.
3. School districts shall implement the provisions (under Chapter 75) in a manner which will enable all students to participate actively in a well-balanced curriculum and master, to the best of their abilities, the knowledge, skills, and competencies established through the
4. Specialized personnel and regular program personnel shall be jointly responsible for the cooperative delivery of effective instruction in the essential elements, as appropriate.

RESPONSIBILITIES OF THE VOCATIONAL EDUCATOR

The primary responsibility of the vocational educator in the curriculum modification process is to help the special needs student establish and reach realistic occupational goals. In an effort to accomplish this, the vocational educator must identify the following.

1. Pertinent information about what will be taught in a vocational program.
2. Necessary requirements for program completion.
3. Multiple exit points (jobs that the learner can prepare for in a vocational program).
4. Entry level competencies expected by employers for each of the exit points.

It is also the responsibility of every vocational educator to establish an effective and wholesome learning environment for their students. Providing this environment may involve modifying the vocational facility, equipment, tools, and/or instruction. This information will be provided in the following section.

MODIFICATION OF THE LEARNING ENVIRONMENT

The term "learning environment" refers to both the **physical** and **instructional** setting of the vocational classroom/laboratory. It is the responsibility of each vocational educator to work at developing a learning environment which will contribute to the overall well-being and success of every student. The key factors found in a wholesome learning environment are those which promote:

1. **Safety, organization, and physical comfort.** In the vocational laboratory, it is absolutely crucial that each student abide by safety rules set by the instructor. In addition, the

laboratory should be kept well organized and clean. A laboratory which is safe, well organized, and physically comfortable helps promote high morale and good work habits.

2. **Respect and acceptance.** Within an effective learning environment, students will show respect not only for the instructor but for each other as well. The instructor should be the student's best role model. The care and acceptance given by the instructor to each student (disabled or nondisabled) will go a long way in promoting peer acceptance, a positive attitude, and healthy self-esteems.

3. **Discipline.** A wholesome learning environment is one which promotes discipline and a positive self-concept within each student. Inappropriate behavior has the potential to seriously affect classroom safety, morale, and the overall learning process. Ways in which the instructor can help the student modify inappropriate behavior include: (a) utilizing the time-out technique, (b) developing student-teacher contracts, (c) ignoring negative behavior—whenever possible, and (d) rewarding appropriate behavior with approval and praise.

4. **Flexibility.** An effective learning environment is flexible and can adapt to a special student's unique needs (i.e., slower rate of learning, inability to access regular tools/equipment, or remedial needs in reading or math for instance). A flexible environment fosters individualized programs through which a special learner can develop marketable skills for employment.

For information on modifying facilities, equipment, and tools for a vocational classroom refer to the *Vocational Special Needs Teacher Training Curriculum*, available through the Extension Instruction and Materials Center.

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Answers to Exercises

A-1: Review of DC and AC Circuits

Instructor's Note: The students' background in algebra will help them understand how Ohm's law defines the relationship between voltage, current, and resistance.

1. Which of the following is the Thevenin equivalent voltage for figure 6?
   A. 5.9 V
   B. 6.8
   C. 7.7 V
   D. 8.6 V
   E. None of the above

2. Which of the following is the Thevenin equivalent resistance for figure 6?
   A. 13.4 kΩ
   B. 18.9 kΩ
   C. 24.4 kΩ
   D. 29.9 kΩ
   E. None of the above

3. Which of the following is the Norton equivalent circuit for figure 6?
   A. I_N 1.07 mA, R_N 18.9 kΩ
   B. I_N 3.52 mA, R_N 15.3 kΩ
   C. IN .407 mA, R_N 15.3 kΩ
   D. I_N 7.37 mA, R_N 18.9 kΩ
   E. None of the above

4. Which of the following is the Thevenin equivalent voltage and resistance for a battery with an open circuit voltage of 9 volts and an output voltage of 5 V with a 100 Ω load?
   A. 8 V, 13 Ω
   B. 9 V, 0.2 Ω
   C. 9 V, 0.8 Ω
   D. 9 V, 3.2 Ω
   E. None of the above

5. Which of the following is the time constant for a circuit with a 0.47 μF capacitor and a 12 kΩ resistor?
   A. 0.03 ms
   B. 18.3 ms
   C. 0.235 s
   D. 5.64 ms
   E. None of the above

6. In figure 7, if the resistor is 12 Ω, the capacitor is 0.02 μF, and the inductor is 4.5 mH, which one of the following is the resonant frequency?
   A. 47.3 MHz
   B. 28.2 kHz
   C. 16.8 kHz
   D. 803 Hz
   E. None of the above

7. Assume that the voltage source in figure 7 is 3 kHz and the component values are as listed in question 6. Which of the following is the impedance and the angle θ for the circuit in figure 7?

   A. Z 2.57 kΩ, θ89.7°

   B. Z 12.7 kΩ, θ 38.3°

   C. Z 735 Ω, θ 47.7°

   D. Z 3.14 kΩ, θ 87.2°

   E. None of the above

8. Which of the following is the Q of the circuit in question 6?

   A. 135

   B. 6.42

   C. 7.07

   D. 15.3

   E. None of the above

B-1: Diodes and Atomic Theory

Instructor's Note: The atomic theory studied in chemistry will help students understand how diodes and transistors are constructed and how electrons move in silicon crystals.

1. How many protons does a silicon atom have?

   A. 16

   B. 14

   C. 12

   D. 10

   E. None of the above

2. How much power is dissipated in a diode with the 0.7 V drop and 35 mA of current flowing through it?

   A. 35.6 mW

   B. 24.5 mW

   C. 0.2 W

   D. 1.5 W

   E. None of the above

3. If the voltage coming from the variable supply in figure 8 is 9 V and the resistor R_1 is a 1 kΩ, what is the voltage drop across the diode?

   A. 1.3 V

   B. 1.0 V

   C. 0.7 V

   D. 0.4 V

   E. None of the above

4. What is the maximum number of electrons that can be in the outer or valence orbit of any atom?
   A. 32
   B. 16
   C. 8
   D. 4
   E. None of the above

5. How many electrons should be in the outer orbit of material added to silicon to make P-type material?
   A. 3
   B. 4
   C. 5
   D. 6
   E. None of the above

6. How many electrons are in the outer orbit of a good conductor?
   A. 7
   B. 5
   C. 3
   D. 1
   E. None of the above

7. If the variable voltage supply, in figure 8, is 6 V and the resistor is a 1.2 kΩ, how much current is flowing through the diode?
   A. 3.65 mA
   B. 5.0 mA
   C. 5.58 mA
   D. 4.42 mA
   E. None of the above

8. Use the accurate diode to calculate the bulk resistance with 13 mA of current flowing through the diode and a 0.94 V drop across the diode.
   A. 72.3 Ω
   B. 65.4 Ω
   C. 28.5 Ω
   D. 18.5 Ω
   E. None of the above

9. In figure 8, if the voltage source is 9 V and the resistance is 1 kΩ, what would have failed if the voltage drop across the diode is 0 V?
   A. The resistor failed open.
   B. The diode failed open.
   C. The diode was inserted into the circuit backwards.
   D. The resistor increased in value to 10 kΩ.
   E. None of the above.

10. A 12 V circuit with a 10 kΩ resistor in series with an LED will result in which condition?
    A. The LED will burn out from too much current.
    B. The 1 mA that passes through the LED is not enough to light the diode.
    C. The LED will glow brightly.
    D. The 12 V is too much voltage across the LED.
    E. None of the above

B-2: Rectifiers

Instructor's Note: This is the same sine wave and the same formula that students studied in trigonometry classes. The only difference is that now the students use voltage instead of undefined units.

1. What is the instantaneous voltage at 47° on a sine wave with a peak voltage of 12 V?
   A. 2.28 V
   B. 4.72 V
   C. 6.34 V
   D. 8.78 V
   E. None of the above

2. What is the peak voltage output from a full-wave rectifier that is being driven by 16 V from the secondary of a transformer?
   A. 4 V
   B. 8 V
   C. 12 V
   D. 16 V
   E. None of the above

3. A transformer and bridge circuit is delivering 100 mA to a load. The transformer has an 8 to 1 turns ratio. What size fuse should be specified for the primary of the transformer?
   A. 20 mA
   B. 16 mA
   C. 13 mA
   D. 9 mA
   E. None of the above

4. On a boat, power is often supplied at 400 Hz. What would be the number of pulses per second from a bridge rectifier on this system?
   A. 200 Hz
   B. 400 Hz
   C. 600 Hz
   D. 800 Hz
   E. None of the above

5. What should the peak inverse voltage rating of the diodes in a bridge be if the transformer is connected to the utility and has a 10 to 1 turns ratio?
   A. 24.7 V
   B. 16.3 V
   C. 12.8 V
   D. 8.35 V
   E. None of the above

B-3: Filters and Zeners

Instructor's Note: The students' algebra and trigonometry courses have shown them the difference between an ideal and a real concept. An ideal voltage source is a mathematical concept.

1. What size fuse should be specified for the circuit in figure 8?
   A. 0.9 mA
   B. 1.7 mA
   C. 2.2 mA
   D. 2.7 mA
   E. None of the above

2. What value resistor should be specified for R_S in figure 8?
   A. 180 Ω
   B. 240 Ω
   C. 330 Ω
   D. 470 Ω
   E. None of the above

3. A technician built a large power supply that blows the fuse every time it is turned on. What might be the problem?
   A. The load is not connected to the power supply.
   B. The filter capacitor has failed open.
   C. The sudden rush of current to fill the discharged capacitor is blowing the fuse.
   D. The value of R_S is too high.
   E. None of the above

4. How much ripple is being fed into R_S from the filter capacitor in figure 8?
   A. 3.62 V
   B. 3.07 V
   C. 2.35 V
   D. 1.67 V
   E. None of the above

5. If R_S is 100 Ω, how much current is flowing through the zener?
   A. 120 mA
   B. 37.4 mA
   C. 8.62 mA
   D. 2.35 mA
   E. None of the above

B-4: Diode Circuits

Instructor's Note: The students learned in physics classes how heat flows from a warm object to one that is cooler. Physics has also taught them about the behavior of electrons as they orbit the atom's nucleus.

1. What size resistor should you have in series with an LED in a 9 V circuit?
   A. 270 Ω
   B. 360 Ω
   C. 470 Ω
   D. 560 Ω
   E. None of the above

2. What value will the dc voltage be on the output of a doubler, if the input is 8 V rms?
   A. 16 V
   B. 19 V
   C. 23 V
   D. 27 V
   E. None of the above

3. If each segment in an LED display used 8 mA of current, how much total current would the display use for the number 2?
   A. 16 mA
   B. 32 mA
   C. 40 mA
   D. 56 mA
   E. None of the above

4. A sine wave with a 3 V peak value is fed into a half-wave rectifier using a Schottky diode. What is the output dc voltage?
   A. 3 V
   B. 2.75 V
   C. 1.3 V
   D. 0.7 V
   E. None of the above

5. A varicap diode is across a tank circuit with 10 V dc on the diode. The resonant frequency of the tank circuit is 150 MHz. When the dc voltage is increased by 6 V to 16 V dc, the frequency changes 3 MHz. What would be the new resonant frequency if the dc voltage is reduced by 6 V to 4 V?
   A. 13 MHz
   B. 10 MHz
   C. 7 MHz
   D. 3 MHz
   E. None of the above

6. What value should the resistance be, in series with an LED, if the LED circuit is in the primary of a transformer used in a power supply?
   A. 33 kΩ
   B. 7.7 kΩ
   C. 1.2 kΩ
   D. 470 Ω
   E. None of the above

B-5: Transistor Theory

Instructor's Note: The students learned in physics how heat flows from a warm object to one that is less warm.

1. When a transistor is operating in a linear circuit, what is the voltage drop across the base emitter junction?
   A. 0.3 V
   B. 0.5 V
   C. 0.7 V
   D. 0.9 V
   E. None of the above

2. If the base current of a transistor is 12 μA and the beta is 135, what is the collector current?
   A. 0.29 mA
   B. 0.83 mA
   C. 1.24 mA
   D. 1.62 mA
   E. None of the above

3. What is the beta of a transistor with 2.3 mA of collector current and 20 μA of base current?
   A. 115
   B. 135
   C. 155
   D. 175
   E. None of the above

4. What would be the cutoff voltage for a transistor circuit with 15 V supply and a 1.2 kΩ resistor feeding the collector?
   A. 15 V
   B. 13 V
   C. 11 V
   D. 9 V
   E. None of the above

5. What would the saturation current be for problem 4?
   A. 35 mA
   B. 18.7 mA
   C. 12.5 mA
   D. 8.34 mA
   E. None of the above

B-6: Transistor Switch

Instructor's Note: The students will need to use their knowledge of algebra to understand how a voltage source supplies a transistor and feeds into the collectors of transistors.

1. When the signal voltage is 6 V, what is the emitter voltage on T_1?
   A. 12 V
   B. 0.7 V
   C. 6.7 V
   D. 5.3 V
   E. None of the above

2. In figure 5, when the signal input voltage is at 0 V, what is the voltage on the collector, V_C, of T_2?
   A. 0 V
   B. 0.7 V
   C. 6 V
   D. 12 V
   E. None of the above

3. What is the voltage on the base of transistor T_2, with the signal on?
   A. 12 V
   B. 6.7 V
   C. 0.7 V
   D. 0 V
   E. None of the above

4. What changes would you make to the circuit in figure 5 if V_{CC} changed to 18 V?
   A. Change R_2 to a 4.2 kΩ resistor and R_3 to 1.2 kΩ.
   B. Change R_3 to a 1 kΩ.
   C. Change R_1 to a 3.6 kΩ and R_2 to a 4.2 kΩ.
   D. No changes are needed.
   E. None of the above

5. Assume that the circuit in figure 5 has failed. You find that there is 0 V on the collector of T_2 and 0.7 V on the base of T_2. What is the problem?
   A. Transistor T_2 has failed open.
   B. The LED is open.
   C. Resistor R_2 has shorted.
   D. Transistor T_1 has failed open.
   E. None of the above

6. If transistor T_1 has a beta of 100, what is the base current into this transistor with the 6 V signal voltage on?
   A. 6 μA
   B. 12 μA
   C. 24 μA
   D. 48 μA
   E. None of the above

7. If the LED in figure 5 stays on continually, and you find that the voltage on the emitter of T_1 remains at 12 V with or without the signal voltage, what has failed?
   A. Transistor T_2 has shorted to ground.
   B. Resistor R_3 has shorted.
   C. Transistor T_1 has failed open.
   D. Transistor T_1 has failed shorted.
   E. None of the above

8. You find that the LED does not light when the signal voltage is on and the collector of T_2 has 12 V on it. What has failed?
   A. The LED is open.
   B. Transistor T_1 is open.
   C. Transistor T_2 is open.
   D. Resistor R_3 is shorted.
   E. None of the above

B-7: Transistor Bias

Instructor's Note: The students' background in algebra will help them understand the theory of equivalent input circuits and separate output circuits.

1. Calculate the following voltages for the circuit in figure 6.
   A. V_B for T_1 1.6 V
   B. V_E for T_1 0.9 V
   C. V_C for T_1 8 V
   D. V_B for T_2 2 V
   E. V_E for T_2 1.3 V
   F. V_C for T_2 8.2 V

2. If resistor R_E broke away from the emitter transistor T_1, what would be the following voltages?
   A. V_B for T_1 1.6 V
   B. V_E for T_1 12 V
   C. V_C for T_1 12 V
   D. V_B for T_2 2 V
   E. V_E for T_2 1.3 V
   F. V_C for T_2 8.2 V

3. If transistor T_2 had a short from the collector to the emitter, what would be the following voltages?
   A. V_B for T_1 1.6 V
   B. V_E for T_1 0.9 V
   C. V_C for T_1 8 V
   D. V_B for T_2 2 V
   E. V_E for T_2 3 V
   F. V_C for T_2 3 V

B-8: Transistor Amplifier

Instructor's Note: The use of oscilliscopes is much like the use of graphs the students studied in math courses.

1. What is the dc voltage V_B for the transistor in figure 4?
   A. 1.9 V
   B. 1.5 V
   C. 1.1 V
   D. 0.8 V
   E. None of the above

2. What is the value of V_E in figure 4?
   A. 1.4 V
   B. 1.2 V
   C. 0.84 V
   D. 0.70 V
   E. None of the above

3. What is the value of r_e'?
   A. 6.5 Ω
   B. 9.7 Ω
   C. 12.3 Ω
   D. 14.7 Ω
   E. None of the above

4. Find the gain for the circuit in figure 4.
   A. 21
   B. 35
   C. 16
   D. 42
   E. None of the above

B-9: Multistage Transistor Amplifiers

Instructor's Note: The students' math courses will help them understand the concept of a darlington and how an increase in beta will affect a circuit.

1. What is the approximate input impedance of an emitter follower with two 10 kΩ resistors for the voltage divider on the base and a 1 kΩ resistor for the emitter resistor?
   A. 10 kΩ
   B. 5 kΩ
   C. 2 kΩ
   D. 1 kΩ
   E. None of the above

2. How many degrees of a sine wave will a class B push-pull amplifier amplify?
   A. 360°
   B. 270°
   C. 180°
   D. 90°
   E. None of the above

3. What is the total beta of a darlington made from two transistors with betas of 75 and 250?
   A. 57380
   B. 18750
   C. 325
   D. 175
   E. None of the above

4. What is the voltage gain of a push-pull circuit with a 10 kΩ, a 1 kΩ, and two diodes in its bias network?
   A. 100
   B. 10
   C. 1
   D. 0.5
   E. None of the above

5. What is the gain in decibels for a two-stage amplifier, with a gain of 59 for the first transistor, a loss between the transistors of 0.6, and a final loss between the second transistor and the load of 0.5? The second stage is an emitter follower.
   A. 57
   B. 38
   C. 12
   D. 25
   E. None of the above

6. What is the power in watts for 36 dBm?
   A. 6.35 W
   B. 248 mW
   C. 3.98 W
   D. 1.2 W
   E. None of the above

B-10: Oscillators and Feedback

Instructor's Note: The students studied the concept of feedback in speaker systems in their physics courses.

1. In an oscillator circuit, if the gain of the amplifier is 15, what is the loss in the feedback network?
   A. 0.7
   B. 0.3
   C. 0.07
   D. 0.03
   E. None of the above

2. If the positive feedback were coming into the emitter of a transistor, which leg of the transistor could you move this feedback to in order to get negative feedback?
   A. Move it to the base.
   B. Move it to the collector.
   C. Leave it on the emitter, and add a capacitor.
   D. It cannot be done.
   E. None of the above

3. Rank the following in descending order for the value of their Q: ceramic device, quartz crystal, coil and capacitor.
   A. Quartz crystal, ceramic device, and coil and capacitor
   B. Ceramic device, quartz crystal, and coil and capacitor
   C. Coil and capacitor, ceramic device, and quartz crystal
   D. Ceramic device, coil and capacitor, and quartz crystal
   E. None of the above

4. What do you look for when you are troubleshooting a problem oscillation?
   A. A failed component
   B. The oscillation
   C. The positive feedback path
   D. The source of power to the circuit
   E. None of the above

5. What is the equivalent circuit for a crystal?
   A. A resonant tank circuit with additional resistance
   B. A choke and capacitor combination with series resistance
   C. A series resonant circuit with a small amount of series resistance
   D. A varicap diode and a coil
   E. None of the above

6. If the impedance in a positive feedback network is doubled, what would have to happen with the amplifier to keep the oscillator going?
   A. The gain of the amplifier would have to drop by 50%.
   B. The gain of the amplifier would have to increase by 50%.
   C. The gain of the amplifier would have to double.
   D. The gain of the amplifier would have to triple.
   E. None of the above

7. Why would the manufacturer of a circuit board build a small oven on the board?
   A. To keep the transistors from getting cold
   B. To extend the life of the circuitry
   C. To maintain a constant frequency
   D. To keep the crystal from freezing
   E. None of the above

B-11: Voltage Regulation

Instructor's Note: The students will use math studied in their algebra classes to compute the variation in the load voltage in a zener-regulated circuit.

1. How much resistance would you specify for the series resistor in a zener regulator circuit with an unregulated voltage of 22 V and a zener voltage of 13 V? The load on this circuit requires 50 mA. Use your calculated value.
   A. 470 Ω
   B. 180 Ω
   C. 120 Ω
   D. 47 Ω
   E None of the above

2. What is the unregulated voltage or voltage across C_1 in figure 6?
   A. 24 V
   B. 18 V
   C. 32 V
   D. 16 V
   E. None of the above

3. In figure 6, what is the voltage, V_B, at the base of Q_4?
   A. 0.7 V
   B. 12 V
   C. 5.3 V
   D. 6.7 V
   E. None of the above

4. If the current limiting has just started in the circuit in figure 6 and there is a 2 V drop across R_3, what is the voltage from the wiper measured from R_3 to the wiper of R_4?
   A. 2.3 V
   B. 0.95 V
   C. 1.8 V
   D. 1.3 V
   E. None of the above

5. If R_5 has been adjusted to give 9 V across the load and there is a 1 V drop across R_3, what is the voltage at the base of the darlington?
   A. 12.1 V
   B. 9.4 V
   C. 6 V
   D. 7.2 V
   E. None of the above

6. What is the value of resistance R_3 in question 5?
   A. 1.1 Ω
   B. 1.8 Ω
   C. 0.89 Ω
   D. 0.75 Ω
   E. None of the above

7. If the circuit in figure 6 is maintaining 9 V across the load, what size fuse should this circuit have? Remember to add 50% to your calculated value.
   A. 0.15 A
   B. 0.2 A
   C. 0.5 A
   D. 1.2 A
   E. None of the above

B-12: Other Types of Transistors

Instructor's Note: The students will use their background from chemistry classes to understand the differences between bipolar and unipolar transistors.

1. A JFET that is made from a bar of P-type material with islands of N-type material is called—
   A. PN channel
   B. P-channel
   C. N channel
   D. Constant current diode
   E. None of the above

2. An N-channel JFET will need what voltage on its gate to operate as a linear amplifier?
   A. From 4 to 6 V
   B. V_{GSoff}
   C. Half of V_{DD}
   D. Negative
   E. None of the above

3. What is the voltage on the gate when the depletion layer pinches off the current flow?
   A. +12 V
   B. V_{GSoff}
   C. I_{DSS} times R_{DSon}
   D. 3.5 V
   E. None of the above

4. What is the term for the maximum amount of current a JFET can conduct?
   A. I_{DSS}
   B. I_{Dmax}
   C. I_{Csat}
   D. I_{DS}
   E. None of the above

5. What is the formula for calculating R_S in a self-biased JFET?
   A. $RS = I_{DSS}/V_{GSoff}$
   B. $RS = V_{GSoff}/R_{DSon}$
   C. $RS = I_{DSS}/R_{DSon}$
   D. $R_S = V_{GSoff}/I_{DSS}$
   E. None of the above

6. How is a constant current diode made?
   A. It is made by fusing N-type material to P-type material.
   B. The gate of a JFET is connected to its source.
   C. It is made from power supply circuits in an integrated circuit package.
   D. A transistor circuit is encapsulated into a diode package.
   E. None of the above

7. What is a safe level of gate current that a MOSFET can handle?
   A. 5 µA
   B. 10 mA
   C. 0.01 µA
   D. 0.001 µA
   E. None of the above

B-13: Thyristors

Instructor's Note: The students' studies in chemistry and physics classes will help them understand how the thyristor family of devices work.

1. What is the minimum gate voltage that will turn on an SCR?
   A. 0.2 V
   B. 0.7 V
   C. 1.4 V
   D. 3.75 V
   E. None of the above

2. Which of the following changes would allow the circuit in figure 5 to work with a 5 V power supply?
   A. Change the value of resistor R_4.
   B. Change the SCR to one that will work with this small voltage.
   C. Change resistors R_1 and R_3 to correct the limits.
   D. Change the zener to something less than 5 V.
   E. None of the above

3. If the crowbar circuit in figure 5 was set to trigger at 12 V by adjusting the potentiometer while the circuit was at 12 V, what would be the voltage of the wiper of the pot if the supply jumped to 24 V?
   A. 6 V
   B. 12 V
   C. 24 V
   D. 18 V
   E. None of the above

4. How many times would an SCR have to be triggered during three cycles of a sine wave to keep it conducting?
   A. 1 time
   B. 2 times
   C. 3 times
   D. 4 times
   E. None of the above

5. Which of the following methods would force an SCR to turn on?
   A. Momentarily short the anode to ground.
   B. Use some high-voltage pulses feeding the line into the SCR.
   C. Suddenly reduce the current into the SCR.
   D. Induce a mechanical shock to the device.
   E. None of the above

6. A solid-state relay is a circuit made to operate like a relay and frequently used to replace a conventional relay. If the solid-state relay is made using SCRs, how many SCRs would it take to make a 4-pole, single-throw relay?
   A. 2 SCRs
   B. 3 SCRs
   C. 4 SCRs
   D. 5 SCRs
   E. None of the above

7. Which of the following methods can be used to turn an SCR off?
   A. Short the gate to V_{CC}.
   B. Increase the voltage above the overvoltage limit.
   C. Disconnect the capacitor resistor filtering system.
   D. Reverse-bias the gate.
   E. None of the above

C-1: Op-Amp Theory

Instructor's Note: Making a semiconductor involves chemical processes the students studied in chemistry.

1. Approximately what percentage of integrated circuits include an inductor in their circuitry?
   A. 0.5%
   B. 1.0%
   C. 5%
   D. 10%
   E. None of the above

2. What is the relationship between the frequency and the gain of an op-amp?
   A. The gain is not affected by the frequency.
   B. When the frequency gets high enough, the gain will suddenly drop down to unity.
   C. The gain of the circuit is progressively reduced as the frequency is increased.
   D. The higher the frequency, the higher the gain.
   E. None of the above

3. What material is formed when oxygen is blown on a silicon wafer?
   A. Impurities are added, resulting in N-type or P-type material.
   B. The oxygen increases the conductivity of the surface.
   C. A layer of glass is formed on the surface.
   D. The impurities are burned off, reducing the doping at the surface.
   E. None of the above

4. If an op-amp with 4.7 V on V_1 and 4.6 V on V_2 has a voltage gain of 100, what will the output voltage be?
   A. 100 V
   B. 50 V
   C. 12 V
   D. 10 V
   E. None of the above

5. Which one of the following terms would represent a chip that could store over a million bits of information?
   A. MSI
   B. LSI
   C. SMI
   D. VLSI
   E. None of the above

6. If the dual power supplies when added together equal 24 V, what is the maximum peak-to-peak voltage that the output of an op-amp can approach?
   A. 6 V
   B. 12 V
   C. 24 V
   D. 36 V
   E. None of the above

7. A differential input of 1 mV results in 0.5 V output and the same input fed in to both inputs as a common mode signal will result in an output of 5 mV. What is the CMRR?
   A. 500
   B. 250
   C. 100
   D. 10
   E. None of the above

8. With a peak voltage of 4 V, what is the maximum frequency that a 741c op-amp can amplify without slew rate distortion?
   A. 5.7 kHz
   B. 10 kHz
   C. 20 kHz
   D. 27.3 kHz
   E. None of the above

C-2: Op-Amp Amplifiers I

Instructor's Note: The students' studies in mathematics will help them understand the concept of negative feedback.

1. In figure 5, R_F is 18 kΩ. What is the gain of this op-amp circuit?
   A. 20.2
   B. 9.25
   C. 18.0
   D. 6.3
   E. None of the above

2. In figure 5, if there is a 3 mV rms signal input to the circuit and the same 18 kΩ resistor for R_F, how much signal would you see on pin 2 of the op-amp?
   A. 3 mV rms
   B. 2 mV rms
   C. 1 mV rms
   D. 0 mV rms
   E. None of the above

3. In the circuit in figure 6, what should the value of R_1 be for a gain of 12, if R_2 is a 1 kΩ resistor?
   A. 10 kΩ
   B. 6 kΩ
   C. 22 kΩ
   D. 11 kΩ
   E. None of the above

4. In figure 6, R_1 is equal to 51 kΩ and R_2 is equal to 1.8 kΩ. What is the closed loop gain?
   A. 28.3
   B. 29.3
   C. 49.2
   D. 37.4
   E. None of the above

5. If all of the output is connected back to the input on a 741c, what is the upper cutoff frequency?
   A. 250 kHz
   B. 500 kHz
   C. 1 MHz
   D. 2 MHz
   E. None of the above

6. What is the slew rate of a 741c op-amp?
   A. 5 V/μs
   B. 12
   C. 0.5 V/μs
   D. 36
   E. None of the above

7. In figure 6, what is the closed loop input impedance of the 741c op-amp, if the open loop gain "A" is 100,000, and R_1 and R_2 give a closed loop gain of 6? The open loop input impedance of the op-amp is 2 MΩ.
   A. 16,000 MΩ
   B. 33,000 MΩ
   C. 47,000 MΩ
   D. 870 MΩ
   E. None of the above

C-3: Op-Amp Amplifiers II

Instructor's Note: By adding voltages and using their knowledge of algebra, the students will be able to understand how the single voltage supply concept works.

1. In figure 6, if the emitter follower has an output impedance of 30 Ω without the negative feedback and the open loop gain is 100,000, what is the output impedance with the negative feedback?
   A. 5 Ω
   B. 0.3 mΩ
   C. 0.02 μΩ
   D. 1.3 mΩ
   E. None of the above

2. If the Z_{out} is 600 Ω and the gain is 20 in figure 6, what is the resistance value of R_F?
   A. 120 kΩ
   B. 30 Ω
   C. 12 kΩ
   D. 8.7 kΩ
   E. None of the above

3. If there is a 15 mV source driving the circuit in figure 6 and you used a scope probe to observe the signal on the input between the capacitor and the op amp, approximately how much voltage would you see?
   A. 15 mV
   B. 7.5 mV
   C. 5 mV
   D. 2.5 mV
   E. None of the above

4. In figure 7, what is the ac output compliance or the maximum voltage swing that is available on the output?
   A. 15 V
   B. 12 V
   C. 6 V
   D. 10 V
   E. None of the above

5. In figure 7, if the capacitor C_3 has 1 kΩ of reactance and R_1 is 6.8 kΩ, what is the gain of the circuit?
   A. 5.7
   B. 3.8
   C. 4.8
   D. 3.4
   E. None of the above

6. In figure 7, what is the input impedance?
   A. 50 kΩ
   B. 25 kΩ
   C. 12.5 kΩ
   D. 100 kΩ
   E. None of the above

7. In figure 7, what value should resistor R_1 be for a gain of 25?
   A. 86 kΩ
   B. 14.9 kΩ
   C. 45.0 kΩ
   D. 43 kΩ
   E. None of the above

C-4: Op-Amp Amplifiers III

Instructor's Note: The students learned in mathematics to take an expression and combine it with other expressions to make a more complex mathematical statement. They do the same here by looking at each of the circuits as a collection of building blocks.

1. If we combined a high-pass filter with a cutoff of 25 kHz and a low-pass filter with a cutoff of a 24 kHz, what kind of filter would we have?
   A. Band pass
   B. High pass
   C. Band reject
   D. Low pass
   E. None of the above

2. How much attenuation of the signal, per decade, will a two-pole, low-pass filter have?
   A. 20 dB
   B. 30 dB
   C. 40 dB
   D. 50 dB
   E. None of the above

3. How much gain does the circuit in figure 6 have from input A only?
   A. 0.75
   B. 0.5
   C. 0.25
   D. 0.125
   E. None of the above

4. If there is 5 V on all inputs in figure 6, what is the output voltage?
   A. 9.375 V
   B. 15.25 V
   C. 6.025 V
   D. 12.325 V
   E. None of the above

5. What is the voltage on the output in figure 7 if the gate voltage on the JFET has resulted in an R_{DS} of 1 kΩ and there is 10 mV on the input?
   A. 1.38 V
   B. 690 mV
   C. 427 mV
   D. 275 mV
   E. None of the above

6. In figure 7, what is the input impedance of the circuit?
   A. 20 kΩ
   B. 10 kΩ
   C. 5 kΩ
   D. 2.5 kΩ
   E. None of the above

C-5: Nonlinear Op-Amp Circuits

Instructor's Note: The students studied the difference between a linear and a nonlinear circuit in computer mathematics.

1. If you switched the polarity on the op-amp of an inverting voltage amplifier, what would the circuit resemble?
   A. Integrator
   B. Schmitt trigger
   C. Differentiator
   D. A mistake
   E. None of the above

2. What kind of feedback does the Schmitt trigger use to create hysteresis?
   A. Induced
   B. Negative
   C. Actual
   D. Positive
   E. None of the above

3. What is the difference between the turn-on voltage and the turn-off voltage for a Schmitt trigger called?
   A. Hysteresis
   B. Difference voltage
   C. Trigger voltages
   D. Noise pulse
   E. None of the above

4. Which input should be used for the input on a simple comparator if the output must go low when the input signal goes high?
   A. Positive
   B. Either input will work.
   C. A comparator will not invert the output.
   D. Inverting
   E. None of the above

5. The output of an open collector comparator circuit is feeding a circuit that requires 5 V and 3 mA. What size should the pull-up resistor be?
   A. 16.7 kΩ
   B. 4.7 kΩ
   C. 1.7 kΩ
   D. 1.2 kΩ
   E. None of the above

6. If we parallel three open collector output circuits and one is turned on and the other two are turned off, what voltage would there be on the output if the single supply voltage is 12 V?
   A. 12 V
   B. 6 V
   C. 11 V
   D. 0 V
   E. None of the above

7. How fast will a 741c op-amp switch 10 V?
   A. 28 ms
   B. 20 µs
   C. 15 µs
   D. 35 µs
   E. None of the above

C-6: 555 Integrated Circuit

Instructor's Note: In computer mathematics or Boolean algebra, the students studied the concept of putting a bar over a reciprocal expression.

1. The flip-flop inside a 555 timer chip has three inputs. What should be on this inputs for the output to go high?
   A. Set high, reset low, and clear high
   B. Set low, reset low, and clear high
   C. Set low, reset low, and clear low
   D. Set low, reset high, and clear high
   E. None of the above

2. What are the 556 and 558 chips?
   A. The 556 and 558 are more complex timer circuits.
   B. The 556 is two 555s, and the 558 is four 555s.
   C. The 556 and 558 are modified op-amps.
   D. The 556 and 558 are single timer chips made by other companies.
   E. None of the above

3. What will the output be on the flip-flop inside a 555 timer chip if there is a low on the clear input and a high on the set input?
   A. Approximately 12 V
   B. Approximately 6 V
   C. Approximately 0 V
   D. Approximately 2 V
   E. None of the above

4. If the switch were shorted on the one shot pulse generator that you studied, what circuit would it resemble?
   A. Integrator
   B. Schmitt trigger
   C. Inverter
   D. Pulse generator
   E. None of the above

5. How long will the pulse length be with a 1 MΩ resistor and a 4 μF capacitor in the 555 timing circuit?
   A. 8.3 s
   B. 4.4 s
   C. 32.7 ms
   D. 14.7 ms
   E. None of the above

6. What are the two trigger voltages inside a 555 timer chip if V_{CC} is 12 V?
   A. 4 and 8 V
   B. 3 and 7 V
   C. 4 and 9 V
   D. 3 and 8 V
   E. None of the above

7. What is the reason for a capacitor between pin 5 and ground on the 555 chip?
   A. Improves the appearance of the circuit
   B. Reduces the possibility of oscillation
   C. Adds timing function to the control input
   D. Filters out noise and ripple
   E. None of the above

C-7: AM and FM Modulation

Instructor's Note: The students studied the basic sine wave in their trigonometry classes. A sine wave is a fundamental wave in nature.

1. The FCC has set a maximum deviation for commercial broadcast stations. What is this maximum deviation?
   A. 5 kHz
   B. 75 kHz
   C. 45 kHz
   D. 1,600 kHz
   E. None of the above

2. Which section of a radio receiver will provide most of the selectivity?
   A. Filter section
   B. I.F. section
   C. Mixer section
   D. Tuned circuits in the R.F. amplifier
   E. None of the above

3. What is a *beat frequency oscillator*?
   A. An oscillator that develops a musical beat
   B. An oscillator used in an AM transmitter
   C. A type of mixer oscillator
   D. Signal used to complete a single sideband signal
   E. None of the above

4. What is the basic wave that is found in nature?
   A. Square wave
   B. Flat wave
   C. Sawtooth wave
   D. Sine wave
   E. None of the above

5. What is the frequency of the first I.F. in an FM receiver?
   A. 455 kHz
   B. 100 MHz
   C. 10.7 MHz
   D. 89.3 MHz
   E. None of the above

6. Which of the following signals will have both odd and even harmonics?
   A. Square wave
   B. Sine wave
   C. Signal output from a bridge rectifier
   D. Triangle wave
   E. None of the above

7. What is the I.F. in a single conversion AM receiver?
   A. 10.7 MHz
   B. 455 kHz
   C. 100 MHz
   D. 89.3 MHz
   E. None of the above

8. What is the Foster-Seeley circuit?
   A. FM detector circuit
   B. AM modulation circuit
   C. FM modulation circuit
   D. AM detector circuit
   E. None of the above

9. What is it called when the audio signal changes the carrier frequency?
   A. Audio detection
   B. Amplitude modulation
   C. Frequency modulation
   D. Error detection
   E. None of the above

C-8: Video Monitoring Systems

Instructor's Note: The students' study of small particle behavior, light energy, and Boyle's gas laws in their physics courses will help them understand the concepts presented in this assignment.

1. What three colors are used for the three color guns in a picture tube?
   A. Blue, yellow, and red
   B. Green, yellow, and red
   C. Red, blue, and green
   D. Orange, yellow, and violet
   E. None of the above

2. How many scanning lines are there across the face of the picture tube?
   A. 750
   B. 525
   C. 425
   D. 375
   E. None of the above

3. How many video pictures have to be presented per second to avoid flicker on a video monitor?
   A. 250
   B. 45
   C. 120
   D. 60
   E. None of the above

4. What does the grid do in a picture tube?
   A. Screens out the electrons
   B. Controls the amplitude of the electron beam
   C. Changes the direction of the electron beam
   D. Attracts the electrons
   E. None of the above

5. How high are the voltages on a picture tube?
   A. From 10,000 to 30,000 V
   B. From 60,000 to 120,000 V
   C. From 5,000 to 15,000 V
   D. Over 130,000 V
   E. None of the above

6. What happens to the electrons after they strike the phosphor coating on the face of the tube?
   A. They drift to the anode or conductive coating inside the tube.
   B. They are absorbed by the positive ions in the tube.
   C. They remain imbedded in the phosphor coating.
   D. They bounce back toward the gun.
   E. None of the above

7. What is the primary advantage of the electromagnetic deflection system over the electrostatic deflection system?
   A. The electromagnetic system requires less current.
   B. The electrostatic deflection is more expensive.
   C. The electromagnetic system can achieve greater deflection.
   D. The electromagnetic system is not affected by voltage surges.
   E. None of the above

D-1: Introduction to Digital

Instructor's Note: The students' studies in algebra and trigonometry will help them understand the difference between analog and digital.

1. Which of the following is a digital device?
   A. Microphone
   B. Ruler
   C. Calculator
   D. Record player
   E. None of the above

2. Where would pin 8 be on a 14-pin DIP with the notch at the top?
   A. Top left corner
   B. Top right corner
   C. Bottom left corner
   D. Bottom right corner
   E. None of the above

3. The 14-pin DIP uses which two pins for V_{CC} and ground?
   A. VCC is pin 7, and ground is pin 14
   B. V_{CC} is pin 14, and ground is pin 7
   C. V_{CC} is pin 5, and ground is pin 10
   D. V_{CC} is pin 1, and ground is pin 7
   E. None of the above

4. Which of the following is part of a microprocessor system and would not be included in a digital circuit?
   A. Memory circuits
   B. Logic voltages of 5 and 0 V
   C. Input data in the form of pulses
   D. Program
   E. None of the above

5. What two voltages are standard for digital pulses?
   A. 0 V and 5 V
   B. 1 V and 4.5 V
   C. 0 V and 12 V
   D. 5 V and 10 V
   E. None of the above

6. What is the memory chip called that cannot be changed or programmed in the field?
   A. RWM
   B. ROM
   C. RAM
   D. PROM
   E. None of the above

7. What do you call the integrated circuit memory chip that can be changed or programmed in the circuit?
   A. RWM
   B. ROM
   C. RAM
   D. PROM
   E. None of the above

8. For what purpose is a hard disk used?
   A. To keep the program in sequence
   B. To separate out weak pulses
   C. To store data
   D. To provide a buffer between hard and soft data
   E. None of the above

9. How accurately, in gallons, will a digital display with three digits read a tank of fuel that holds 20 gallons when full?
   A. Nearest half gallon
   B. Nearest tenth of a gallon
   C. Nearest gallon
   D. 0.001 gallon
   E. None of the above

D-2: Binary, Hex, and Decimal Systems

Instructor's Note: Part of this lesson will be a review of what the students studied in computer mathematics.

1. What is the number 37_{10} in binary coded decimal?
   A. 100101
   B. 0011 0111
   C. 0100 0101
   D. 0011 0011
   E. None of the above

2. Convert the number 14 to hexadecimal.
   A. B
   B. C
   C. D
   D. E
   E. None of the above

3. What is there about a binary number in the 2s complement system that allows the computer to recognize it as a negative number?
   A. It is an illegal binary number.
   B. It always has a 0 in the LSB position.
   C. The 1 is in the MSB position.
   D. The number becomes a true binary when inverted.
   E. None of the above

4. Change the number 111011_2 to hexadecimal.
   A. 32_{16}
   B. 3A
   C. 3B
   D. 3C
   E. None of the above

5. What would the base of a numbering system be if it only had the digits 0, 1, 2, and 3?
   A. Base 3
   B. Base 4
   C. Base 5
   D. Base 6
   E. None of the above

6. Counting up, what are the next five digits that follow the number $F9E_{16}$?
   A. F9F, F00, F01, F02, F03
   B. F9F, F10, F11, F12, F13
   C. F9F, FA1, FA2, FA3, FA4
   D. F9F, FA0, FA1, FA2, FA3
   E. None of the above

7. What is the number -5 in its 2s complement form of a binary number?
   A. 0011_2
   B. 1011_2
   C. 1110_2
   D. 1101_2
   E. None of the above

8. The highest digit in the decimal system is 9. What is the highest digit in the octal system?
   A. 8
   B. 7
   C. 6
   D. 5
   E. None of the above

9. What two decimal numbers represent the largest 3-bit and the largest 4-bit binary numbers?
   A. 8 and 16
   B. 9 and 18
   C. 7 and 15
   D. 6 and 15
   E. None of the above

D-3: Logic Gates and Diagrams

Instructor's Note: The students' study in basic algebra will help them understand the Boolean algebra presented in this assignment.

1. How can you include all possible inputs when making up a truth table?
   A. Include more inputs than what is required to avoid missing any.
   B. If you have a 1 and a 0 on each of the inputs at some point in the truth table, then you have covered all possible inputs.
   C. We do not usually include all inputs because there are too many of them.
   D. Make the inputs to the truth table by counting in binary.
   E. None of the above

2. What circuit would a NAND gate with its inputs tied together resemble?
   A. NOT gate
   B. AND gate
   C. OR gate
   D. NOR gate
   E. None of the above

3. If a digital waveform is fed into one input of a two-input NOR gate with the other input connected to ground, what will the output signal be?
   A. The output will resemble the input.
   B. The output will stay high.
   C. The output will be a continuous 0.
   D. The output will be the input waveform inverted.
   E. None of the above

4. What do the bubbles mean when they are on the output of a large digital circuit?
   A. The output will always be forced to 0.
   B. The output is active low.
   C. Only a 1 on the output will be considered an active output.
   D. It means the output must have an open collector circuit.
   E. None of the above

5. What would the output from a NAND gate be if we put a 0 on one input and fed the other input from a NOR gate with two inputs? One input of the NOR gate is receiving a pulsed input, and the other input is 0.
   A. The output pulse inverted to the input pulse
   B. Output pulse equal to the input pulse
   C. Logic 0
   D. Logic 1
   E. None of the above

6. If you looked at a logic 1 of a TTL circuit on the oscilloscope, what would it look like?
   A. Approximately 0 V
   B. A series of pulses
   C. A voltage of approximately 4 to 5 V
   D. You cannot see logic.
   E. None of the above

D-4: Boolean Algebra

Instructor's Note: Much of this lesson is a review of computer mathematics studied in advanced algebra and trigonometry.

1. Use the rules for Boolean algebra to simplify the Boolean expression, X = (B+BC)+B'.
   A. X = B
   B. X = 0
   C. X = 1
   D. X = BC'
   E. None of the above

2. Use the rules for Boolean algebra to simplify the Boolean expression, X = (A+BC)(A'C').
   A. X = 1
   B. X = AC'
   C. X = B
   D. X = 0
   E. None of the above

3. Select the correct Boolean expression for the logic diagram in figure 4.
   A. X = (B+C)(A+B)'DE
   B. X = (B+C)'(A+B)DE
   C. X = (B+C)'(A+B)D'E
   D. X = (A+B)DE
   E. None of the above

4. Select the correct Boolean expression for the logic diagram in figure 5.
   A. X = {[BC+A](AB+CD)'B}'
   B. X = [(BC)'(AB+CD)'B]'
   C. X = {[(BC)'+A](AB+CD)'B}'
   D. X = [(BC)'+A](AB+CD)'
   E. None of the above

5. Select the correct Boolean expression for the logic diagram in figure 6.
   A. X = {B'[A+(BC)']}'(BD'+C)'D'
   B. X = {(BC)'[A+(BC)']}'(BD'+C)'
   C. X = (BC)'[A+(BC)'](BD'+C)'D'
   D. X = {(BC)'[A+(BC)']}'(BD'+C)'D'
   E. None of the above

D-5: XOR and XNOR

Instructor's Note: The students will use their background in mathematics to understand the circuits presented in this assignment.

1. How many XOR gates would you need to build a circuit that would compare BCD numbers?
   A. 2
   B. 3
   C. 4
   D. 5
   E. None of the above

2. What is the maximum output voltage for a valid low from the output of a TTL circuit?
   A. 0.2 V
   B. 0.3 V
   C. 0.4 V
   D. 0.5 V
   E. None of the above

3. What is the minimum output voltage for a valid logic high on a TTL circuit?
   A. 2.2 V
   B. 2.4 V
   C. 2.6 V
   D. 2.8 V
   E. None of the above

4. What voltage will a noise pulse have to exceed to cause a problem in TTL circuits?
   A. 0.8 V
   B. 0.6 V
   C. 0.4 V
   D. 0.2 V
   E. None of the above

5. What does the term *fan out* mean?
   A. A unit of cooling necessary to keep the circuits from overheating
   B. The number of standard inputs that can be driven by an output
   C. The speed at which the output can drive the inputs
   D. If the fan out is low, bus contention may occur.
   E. None of the above

6. What is the term used to describe the time starting from the receipt of a pulse on the input until the circuit switches on the output?
   A. Bus delay
   B. Tristate time
   C. Field delay
   D. Propagation delay
   E. None of the above

7. Which circuit is similar to the totem pole circuit?
   A. Class A amplifier output
   B. Class C circuit
   C. Class B push-pull circuit
   D. Tristate circuit
   E. None of the above

8. What is the advantage of using tristate logic on the output of some digital circuits?
   A. To increase the fan out
   B. To avoid bus contention
   C. A higher V_{CC} can be used
   D. The propagation delay is reduced.
   E. None of the above

9. What additional component must be added to an open collector output circuit?
   A. Filter capacitor
   B. Pull-up resistor
   C. Output diode
   D. A transistor
   E. None of the above

10. Why should the value of a pull-up resistor be kept high?
   A. To avoid overheating the internal transistor
   B. To reduce the circuit's current consumption
   C. To be sure the output will receive enough current
   D. To make the circuit switch faster
   E. None of the above

11. What do the letters L and S stand for in a 74LS00 IC?
   A. Low speed and Smart logic
   B. Low current and high Speed
   C. Less time and Short delay
   D. Lower cost and Stronger circuitry
   E. None of the above

12. What change do circuit designers make to reduce the current consumption in digital ICs?
   A. Add Schottky diodes
   B. Reduce the base current in the internal transistors
   C. Lower the V_{CC}
   D. Increase the resistance
   E. None of the above

E-1: Flip-Flops

Instructor's Note: The students' background in mathematics will help them understand this assignment.

1. What will be on the Q output after 3 and 8 clock pulses for a J-K flip-flop that starts with a 1 on the Q output and is set up for toggling?
   A. 0, 0
   B. 0, 1
   C. 1, 0
   D. 1, 1
   E. None of the above

2. What logic will be on the Q output if a clock signal is coming into the set input of a set clear FF with active high inputs and the clear input is at 0?
   A. Inverted clock pulse
   B. Steady high
   C. Steady low
   D. Clock pulse
   E. None of the above

3. What logic has to be on all four inputs of a J-K FF for it to toggle? Assume that there is a continuous input of clock pulses.
   A. J and K are both low, and the set and clear are active.
   B. The J input has a 1 and the K a 0 with the set and clear inactive.
   C. The J and K are both high with the set high and clear low.
   D. The J and K are both high, and the set and clear are inactive.
   E. None of the above

4. You have two J-K flip-flops set up for toggling, and the Q output of the first is connected to the clock input of the second. The frequency of the clock signal coming into the first is 100 Hz. What is the frequency of the signal coming from the second flip-flop's Q output?
   A. 200 Hz
   B. 100 Hz
   C. 50 Hz
   D. 25 Hz
   E. None of the above

5. What frequency would be on the Q output of a J-K flip-flop that was toggling if a clock signal with a period of 10 ms was fed into the clock input?
   A. 500 Hz
   B. 50 Hz
   C. 100 Hz
   D. 5 Hz
   E. None of the above

6. If a signal and the clock pulse were to arrive at an FF at exactly the same time, what parameter would tell us that the circuit will fail to give us a valid output?
   A. Hold
   B. Set
   C. Propagation delay
   D. Timing
   E. None of the above

E-2: Registers I

Instructor's Note: The students' background in algebra and trigonometry will help them understand registers.

1. What MOD number would a counter with six FFs have?
   A. 32
   B. 64
   C. 68
   D. 16
   E. None of the above

2. What changes would you make in a ripple counter to make it count down instead of up?
   A. Feed the pulses in backwards.
   B. Connect the Q' outputs to the clock inputs.
   C. Reverse the order of the FFs.
   D. Set it to clear on the number 2.
   E. None of the above

3. If each FF in a 5-bit ripple counter had a propagation delay of 108 ns, how long would the propagation delay for the whole circuit be?
   A. 432 ns
   B. 648 ns
   C. 540 ns
   D. 758 ns
   E. None of the above

4. How many clock pulses would you expect the circuit to take to enter the number 10011_2 into a register in parallel?
   A. 1
   B. 3
   C. 6
   D. 9
   E. None of the above

5. What changes would you need to make to use an OR gate instead of a NAND gate to make a MOD 10 counter?
   A. Convert the logic of the OR gate to match the logic of the NAND gate using DeMorgan's theorem.
   B. Pick up the inputs to the OR gate from the inverted outputs of the FFs.
   C. Connect the output of the OR gate to the set inputs of the FFs.
   D. It is not possible to use an OR gate for this purpose.
   E. None of the above

6. What does the small circle and triangle on the clock input to an FF indicate?
   A. The clock input is active during the low portion of the clock pulse.
   B. Triggers on the trailing edge of the clock pulse
   C. Triggers on the leading edge of the clock pulse
   D. The input will only recognize the low portion of the clock input.
   E. None of the above

7. A MOD 8 counter would use how many FFs?
   A. 2
   B. 3
   C. 4
   D. 5
   E. None of the above

8. After 15 clock pulses, what binary number would be on a MOD 10 counter?
   A. 0111_2
   B. 1001^2
   C. 0101_2
   D. 0011_2
   E. None of the above

E-3: Binary Addition

Instructor's Note: This assignment is a review of computer mathematics. A background in algebra will also help students understand the concepts presented in this assignment.

1. What should the inputs be to get a 1 on both the sum and carry out of a single full adder?
   A. 1 on A, 0 on B, and 0 on C_{in}
   B. 0 on A, 1 on B, and 1 on C_{in}
   C. 1 on A, 1 on B, and 1 on C_{in}
   D. 1 on A, 1 on B, and 0 on C_{in}
   E. None of the above

2. The 7483 adder chip has four adders in it. How many 7483 chips would it take to build a 64-bit adder?
   A. 64
   B. 32
   C. 16
   D. 8
   E. None of the above

3. If it takes a carry 65 ns to pass through one adder, how long would it take for a carry to ripple through a 64-bit adder?
   A. 41.6 μs
   B. 10.4 μs
   C. 1.04 μs
   D. 4.16 μs
   E. None of the above

4. What function is missing in OR gate addition that arithmetic addition has?
   A. The OR gate does not have enough outputs.
   B. The OR gate cannot do 2s complement.
   C. The OR gate has no carry function.
   D. The OR gate cannot handle large numbers.
   E. None of the above

5. What is the register called that receives the sum after addition in a full adder circuit?
   A. Accumulator
   B. B register
   C. Parallel adder
   D. XNOR
   E. None of the above

6. How does the computer know when a binary number, in a 32-bit adder, is negative when the number is in the accumulator?
   A. The number is not a valid ordinary binary number.
   B. The MSB will be a 1.
   C. It remembers the status of the number.
   D. Negative numbers are all below zero.
   E. None of the above

7. Why do we need to carry 1 into the adder for the subtraction process?
   A. Because the process loses a bit
   B. To identify a subtraction process instead of division
   C. To fill the empty spaces in the register holding the final results
   D. The 2s complement system requires it.
   E. None of the above

8. What problem would there be if the total carry propagation delay in a 64-bit adder were 5 μs and the clock input to the accumulator would hit 4 μs after the numbers were received by the adder?
   A. The adder would wait for the carry to complete before going on with the addition.
   B. The carry process would jump ahead when the clock input arrived to save the number.
   C. The addition process would fail, and the result would be garbage.
   D. The adder would only respond to every other clock input.
   E. None of the above

E-4: Decoders

Instructor's Note: Students will use their background in algebra in this assignment.

1. List the binary numbers that, if present on the inputs of a BCD to a seven-segment decoder, would activate the segment E.
   A. 1000_2, 0101_2, 0001_2, 0100_2
   B. 0001_2, 0000_2, 1100_2, 1110_2
   C. 0000_2, 0010_2, 0110_2, 1000_2
   D. 1111_2, 0000_2, 0100_2, 0011_2
   E. None of the above

2. What would you use the ripple blanking input for?
   A. To reduce any ripple noise on the display
   B. To cause the blanking to turn on and off
   C. To feed a ripple signal into
   D. To momentarily turn off the display to avoid figures and numbers that should not be displayed
   E. None of the above

3. What is the maximum number of outputs that a decoder with six inputs can have?
   A. 12
   B. 32
   C. 64
   D. 36
   E. None of the above

4. What is the difference between a common anode and a common cathode LED display?
   A. One gives off a red light and the other a green light.
   B. The polarity of the display changes.
   C. One is brighter than the other.
   D. The common anode is more common than the common cathode.
   E. None of the above

5. How many inputs and outputs does a decoder have that will accept up to 32 different binary combinations on its input?
   A. 4 inputs and up to 36 outputs
   B. 6 inputs and up to 32 outputs
   C. 5 inputs and up to 32 outputs
   D. 8 inputs and up to 28 outputs
   E. None of the above

6. What output will the 7442 have if the input is 1010?
   A. a, b, c, d, e, and f
   B. b and c only
   C. a, b, g, c, and d
   D. a, b, c, d, e, f, and g
   E. None of the above

7. What difference is there between an LCD and an LED display?
   A. One handles numbers and the other letters.
   B. The LED is faster than the LCD.
   C. The LED runs at a higher frequency than the LCD.
   D. The LED makes it own light, and the LCD reflects light.
   E. None of the above

E-5: Encoders and Multiplexers

Instructor's Note: The students' background in mathematics will help them understand the new circuits presented in this assignment.

1. Which circuit would you use—a multiplexer, encoder, decoder, or demultiplexer—for a computer to read the status of six remote stations one at a time in sequence?
   A. Encoder
   B. Multiplexer
   C. Decoder
   D. Demultiplexer
   E. None of the above

2. If the four inputs, 5, 3, 2, and 8, on a priority encoder are active, what binary number would be on the output?
   A. 5
   B. 3
   C. 2
   D. 8
   E. None of the above

3. What is the 74147 IC?
   A. Decoder
   B. Multiplexer
   C. Encoder
   D. Demultiplexer
   E. None of the above

4. You have a logic circuit that consists of an XOR gate feeding one input of an XNOR gate, which gives you three inputs and one output. Select the list of correct inputs to the 74151 starting with D0 to make this circuit.
   A. 0, 0, 1, 1, 0, 1, 1, 0
   B. 1, 1, 0, 1, 0, 1, 1, 0
   C. 1, 0, 0, 1, 0, 1, 1, 0
   D. 1, 0, 0, 1, 0, 0, 1, 0
   E. None of the above

5. What does the latch enable on a 74137 do?
   A. It releases the input data to allow it to go to the output.
   B. It allows the output to latch on.
   C. It turns on the chip.
   D. It enters the data into the flip-flops.
   E. None of the above

6. To use a decoder as a multiplexer, what additional input is required?
   A. Latch enable
   B. Enable input
   C. Select input
   D. Extra data input
   E. None of the above

7. What is the 74138 IC?
   A. Decoder/multiplexer
   B. Seven-segment driver
   C. Encoder
   D. Demultiplexer
   E. None of the above

E-6: One Shot and Schmitt Triggers

Instructor's Note: Students will use their background in algebra to work the formulas in this assignment.

1. What voltages will the 7414 inverter with the Schmitt trigger input trigger on?
   A. 2.3 V and 1.2 V
   B. 1.8 V and 0.4 V
   C. 1.3 V and 0.6 V
   D. 1.6 V and 0.8 V
   E. None of the above

2. What is the slowest rise time that is acceptable for TTL circuits?
   A. 100 ns
   B. 50 ns
   C. 50 ms
   D. 250 µs
   E. None of the above

3. Calculate the pulse width from a one shot with 0.1 µF capacitor and 4 kΩ resistor as the external timing components?
   A. 120 µs
   B. 180 µs
   C. 280 µs
   D. 340 µs
   E. None of the above

4. If a transmission gate is in a circuit with 9 V V_{DD}, and the signal being switched is a sine wave, what is the maximum voltage of the sine wave that can be switched?
   A. 4.5 V
   B. 9 V
   C. 12 V
   D. 18 V
   E. None of the above

5. What is the full range of pulse widths that the 74121 can put out?
   A. 45 ns to 230 ms
   B. 120 ns to 1.5 minutes
   C. 30 µs to 28 ms
   D. 30 ns to 28 seconds
   E. None of the above

6. Approximately how much resistance does a transmission gate have when it is on?
   A. 400 Ω
   B. 300 Ω
   C. 200 Ω
   D. 100 Ω
   E. None of the above

7. What is the primary difference between the 74121 and the 74122?
   A. The 74121 is nonretriggerable; the 74122 can be retriggered.
   B. The 74121 has lower current requirements.
   C. The 74122 is CMOS, and the 74121 is TTL.
   D. The 74121 can put out larger pulses than the 74122.
   E. None of the above

E-7: Interface with the Linear World

Instructor's Note: The students' background in algebra will help them to look mathematically at the devices presented here.

1. What is the highest frequency sine wave that you could transfer to digital numbers, if you used the half flash unit with the 1.5 µs waiting time and sampled each wave 10 times?
   A. 9.4 MHz
   B. 2.3 MHz
   C. 6.7 MHz
   D. 15.8 MHz
   E. None of the above

2. If you were going to build an eight-input DAC using the op-amp with the inverting voltage feedback amplifier and an R_F of 1kΩ, what resistor values would you need in the input?
   A. 1 kΩ, 2 kΩ, 3 kΩ, 4 kΩ, 5 kΩ, 6 kΩ, 7 kΩ, 8 kΩ
   B. 1 kΩ, 4 kΩ, 16 kΩ, 64 kΩ, 256 kΩ, 1.024 MΩ, 4.096 MΩ
   C. 1 kΩ, 2 kΩ, 4 kΩ, 6 kΩ, 8 kΩ, 10 kΩ, 12 kΩ, 14 kΩ
   D. 1 kΩ, 2 kΩ, 4 kΩ, 8 kΩ, 16 kΩ, 32 kΩ, 64 kΩ, 128 kΩ
   E. None of the above

3. Give the resolution of a DAC with six inputs as a percentage of the total voltage.
   A. 6.8%
   B. 3.4%
   C. 1.6%
   D. 0.7%
   E. None of the above

4. How many steps does the DAC in question 3 have?
   A. 32
   B. 64
   C. 58
   D. 72
   E. None of the above

5. What is the number of comparators that would be needed for a 9-bit flash A/D?
   A. 255
   B. 511
   C. 1,023
   D. 2,047
   E. None of the above

E-8: Data Transmission

Instructor's Note: High levels of mathematics are used to find ways to locate and avoid errors. The students' background in mathematics will help them understand some of the concepts presented here.

1. What should the impedance of the coax be for a CB antenna?
   A. 100 Ω
   B. 75 Ω
   C. 50 Ω
   D. As low as possible
   E. None of the above

2. How long is an ASCII word in bits?
   A. 32 bits
   B. 16 bits
   C. 8 bits
   D. 7 bits
   E. None of the above

3. Which of the following words is not correct? Each word is using *even* parity and *is a binary coded decimal* for a total of a 5-bit word.
   A. 10100
   B. 11000
   C. 11001
   D. 00110
   E. None of the above

4. The parity system would catch the error if the right two bits were changed. What two bits would have to be changed?
   A. Parity bit and one other
   B. Two that are next to each other
   C. The LSB and the bit next to it
   D. Two 1s or two 0s
   E. None of the above

5. What is the difference between laser light and ordinary light?
   A. Laser light is stronger.
   B. Laser light cannot be reflected like ordinary light.
   C. Laser light is one frequency and in phase, which ordinary light is not.
   D. Ordinary light does not generate heat, and laser light will.
   E. None of the above

6. What is the RS-232C system?
   A. A system for detecting errors in transmitted data
   B. A system of transmitting data in parallel from a computer to a printer
   C. A set of standards for serial transmission of data
   D. A chip for converting parallel data to serial data
   E. None of the above

F-1: Memory Devices

Instructor's Note: The students' background in algebra will help them understand how to work with this system of describing memory.

1. How many bits are in a memory unit with the capacity of 3K X 8?
   A. 24,000
   B. 2,400
   C. 24576
   D. 8,192
   E. None of the above

2. How many address locations are in the memory unit in question 1?
   A. 3,00
   B. 3,072
   C. 8,000
   D. 8,192
   E. None of the above

3. What is the word size for the memory unit in question 1?
   A. 3 bits
   B. 24 bits
   C. 1,024 bits
   D. 8 bits
   E. None of the above

4. What would you call a memory system that used D flip-flops in its registers?
   A. ROM
   B. EPROM
   C. RAM
   D. DRAM
   E. None of the above

5. What do you call a memory system that stores its data on a capacitor?
   A. ROM
   B. EPROM
   C. RAM
   D. DRAM
   E. None of the above

6. What word size does dynamic memory have?
   A. 8 bit
   B. 4 bit
   C. 2 bit
   D. 1 bit
   E. None of the above

7. How is the EPROM reprogrammed?
   A. A higher than normal voltage is used.
   B. Ultraviolet light is used to erase it, and then it is reprogrammed.
   C. A computer is used to download the data.
   D. The chip is heated to erase it and then cooled for reprogramming.
   E. None of the above

8. Why does the computer refresh dynamic memory?
   A. To remove any errors
   B. The registers become tired.
   C. To recharge the internal capacitors
   D. To clear any blank areas for more data
   E. None of the above

9. What type of device is the 74670?
   A. Dynamic memory chip
   B. Address control chip
   C. Static memory device
   D. Interface chip
   E. None of the above

10. How many bits are in a byte, and how many bits in a nibble?
    A. 6 and 4
    B. 8 and 4
    C. 6 and 2
    D. 8 and 16
    E. None of the above

F-2: Microprocessor Theory

Instructor's Note: The students' background in algebra and trigonometry will help them think logically. Thinking logically will help them as they study the microprocessor.

1. How many lines are there in the address bus and the data bus in the 6809 μP system?
   A. 64 bits and 32 bits
   B. 32 bits and 16 bits
   C. 16 bits and 8 bits
   D. 8 bits and 4 bits
   E. None of the above

2. Which bus allows information to go only one way?
   A. Data bus
   B. Control bus
   C. Address bus
   D. School bus
   E. None of the above

3. Which bus system has the line that tells the memory chip to store the data that is on the data bus?
   A. Data bus
   B. Control bus
   C. Address bus
   D. School bus
   E. None of the above

4. How many flags does the condition code register have?
   A. 16
   B. 12
   C. 8
   D. 4
   E. None of the above

5. How many pins does the 6809 μP have?
   A. 120
   B. 80
   C. 40
   D. 32
   E. None of the above

6. What is the name of the register that decodes data from the data bus to determine what step to take next?
   A. PC register
   B. DP register
   C. CC register
   D. Instruction register
   E. None of the above

7. What is the maximum memory that a μP with an 8-bit address bus can access?
   A. 512 bits
   B. 256 bits
   C. 128 bits
   D. 1024 bits
   E. None of the above

8. What is the register called that will increase the address each time it puts an address on the address bus?
   A. Direct page register
   B. Condition code register
   C. Accumulator register
   D. Program counter register
   E. None of the above

9. What is the size of the address bus for the new 68000 series of μP?
   A. 36 bits
   B. 24 bits
   C. 18 bits
   D. 16 bits
   E. None of the above

F-3: Computer Language

Instructor's Note: The students' studies in English and grammar will help them to understand the new language used to communicate with computers. Unlike people, the computer requires accuracy in its communications.

1. What does the dollar sign in front of an address location mean?
   A. It designates an address location.
   B. It reminds the programmer that time is money.
   C. It tells the computer that this address is in hexadecimal.
   D. It tells the computer to find that address.
   E. None of the above

2. What is an *operand*?
   A. Operational part of the instruction
   B. Address location in an instruction word
   C. A type of address location
   D. A method of giving address locations
   E. None of the above

3. What does *position independence* mean?
   A. Writing lines of instruction in any position in the program
   B. The position of the program counter is not important.
   C. This involves address locations that move around.
   D. A program which does not reference a specific address location
   E. None of the above

4. What does the op-code *ADDB* mean?
   A. Add A and B.
   B. Add the data in the specified address location to the data in the B register.
   C. Add the totals in the B register.
   D. Add the B and D registers.
   E. None of the above

5. What does the term *flag* mean to a programmer?
   A. A signal that there is a mistake in the program
   B. A flag indicates the program is running too fast.
   C. A flag shows the condition of the μP.
   D. Flags are used to decorate the program.
   E. None of the above

6. What does the op-code *LDA* mean?
   A. Load the A register contents into the D register.
   B. Leave the A and the D register empty.
   C. Load the A register with the contents of the specified address location.
   D. Remove the contents of the D register to the specified address location.
   E. None of the above

7. What is *Pascal*?
   A. This register is located next to the Y register in the 6809 μP.
   B. Pascal is part of the control bus.
   C. Pascal is a higher level language.
   D. Pascal is part of the I/O devices.
   E. None of the above

8. What is the index addressing mode?
   A. It is a method of sorting the address locations.
   B. The programmer will use this mode to find a location.
   C. This mode will put the address locations far enough away from the main program to avoid problems.
   D. It is an addressing mode that uses the index register to calculate the address location.
   E. None of the above

9. How does documentation affect the program?
   A. It helps guide the program to the correct instructions.
   B. It speeds up the running of the program.
   C. It reduces the number of errors in a program.
   D. The program will not run without it.
   E. None of the above

Answers to Unit Tests and Final Exam

Unit A: Introduction and Review

PRETEST/POSTTEST

NAME Teacher's Key DATE

DIRECTIONS: Use some scrap paper when working out the problems. The answer that you derive may not be a perfect match with one of the choices. The difference can be a result of how you used your calculator or how many places you used in the calculations. If you are sure of your answer and one of the choices is close, then take it for your answer.

1. What is Ohm's law for finding voltage?
   A. V = I/R
   B. V = IR
   C. V = R/I
   D. V = E/RI
   E. None of the above

2. How much current will flow through a 2.7 kΩ resistor that is in parallel with a 12 V source?
   A. 3.7 mA
   B. 6.8 mA
   C. 18.5 mA
   D. 4.4 mA
   E. None of the above

3. What is the Thevenin equivalent circuit for figure 1?
   A. V_{Th} 13 V, R_{Th} 4.7 kΩ
   B. V_{Th} 16 V, R_{Th} 8.3 kΩ
   C. V_{Th} 11 V, R_{Th} 6.8 kΩ
   D. V_{Th} 10 V, R_{Th} 3.6 kΩ
   E. None of the above

4. What is the Norton equivalent circuit for figure 1?
   A. I_N 2.7 mA, R_{Th} 6.5 kΩ
   B. I_N 1.8 mA, R_{Th} 7.1 kΩ
   C. I_N 1.7 mA, R_{Th} 9.3 kΩ
   D. I_N 3.4 mA, R_{Th} 6.9 kΩ
   E. None of the above

5. What is the reactance of a 0.0047 μF capacitor in a circuit at 100 kHz?
   A. 280 Ω
   B. 339 Ω

C. 520 Ω
D. 470 Ω
E. None of the above

6. What is the resonant frequency of a circuit with a 680 pF capacitor and 800 μH coil?
A. 132 kHz
B. 418 kHz
C. 330 kHz
D. 216 kHz
E. None of the above

Unit B: Semiconductors

PRETEST/POSTTEST

NAME Teacher's Key DATE

DIRECTIONS: Use some scrap paper when working out the problems. The answer that you derive may not be a perfect match with one of the choices. The difference can be a result of how you used your calculator or how many places you used in the calculations. If you are sure of your answer and one of the choices is close, then take it for your answer.

1. What is the voltage at point A in figure 1?
   A. 27 V
   B. 24 V
   C. 21 V
   D. 18 V
   E. None of the above

2. What is the voltage at point C in figure 1?
   A. 9 V
   B. 11.3 V
   C. 9.6 V
   D. 10.3 V
   E. None of the above

3. In figure 1, what should the calculated value of the LED resistor R_2 be? Assume a load voltage of 14 V instead of the value you calculated in problem 2. (Calculated value only)
   A. 400 Ω
   B. 570 Ω
   C. 1.2 kΩ
   D. 800 Ω
   E. None of the above

4. In figure 1, what should the value of R_1 be, if the load requires 3 amperes, the beta of Q_1 is 25 and of Q_2 is 120, and the voltage at point A is 16 V? Use the calculated value for the resistance, not the adjusted value to include the additional current.
   A. 8.2 kΩ
   B. 5.7 kΩ
   C. 1.2 kΩ
   D. 12.7 Ω
   E. None of the above

5. In figure 1, calculate the voltage at point B. Use the values on the drawing.
   A. 10.3 V
   B. 11.7 V
   C. 9.6 V

D. 11.0 V
E. None of the above

6. A power transformer used in a linear power supply has a load of 8 Ω. The transformer is putting 12 V across the load. What is the primary current in the transformer?
A. 348 mA
B. 273 mA
C. 235 mA
D. 185 mA
E. None of the above

7. In figure 2, if V_{CC} is 12 V, what is V_B on transistor Q_2?
A. 1.97 V
B. 2.35 V
C. 2.86 V
D. 1.27 V
E. None of the above

8. In figure 2, if V_{CC} is 12 V, what is V_B on transistor Q_3?
A. 10 V
B. 8 V
C. 4 V
D. 6 V
E. None of the above

9. In figure 2, if V_{CC} is 12 V, what is V_E on transistor Q_3?
A. 5.3 V
B. 6.7 V
C. 8.2 V
D. 8.9 V
E. None of the above

10. Calculate the value of $r_{e'}$ (ac emitter resistance) for transistor Q_2 in figure 2. (V_{CC} is 12 V.)
A. 20.2 Ω
B. 17 Ω
C. 14.7 Ω
D. 12.3 Ω
E. None of the above

11. What is the voltage gain of transistor Q_2 in figure 2?
A. 78.3
B. 47.2
C. 31.5
D. 18.7
E. None of the above

12. What is the input impedance (Z_{in}) of transistor Q_2 in figure 2?
A. 470 Ω
B. 1 kΩ
C. 680 Ω
D. 802 Ω
E. None of the above

Unit C: Integrated Circuits

PRETEST/POSTTEST

NAME Teacher's Key DATE

DIRECTIONS: Use some scrap paper when working out the problems. The answer that you derive may not be a perfect match with one of the choices. The difference can be a result of how you used your calculator or how many places you used in the calculations. If you are sure of your answer and one of the choices is close, then take it for your answer.

1. A differential input of 2 mV gives 250 mV output, and the same 2 mV input as common mode gain gives 0.7 mV output. What is the common mode reject ratio?
   A. 489
   B. 357
   C. 275
   D. 146
   E. None of the above

2. If an op-amp amplifier with a gain of 150 has 1.3 V on V_1 and 1.29 V on V_2, what is on the output?
   A. 15 V
   B. 1.3 V
   C. 1.5 V
   D. 0.01 V
   E. None of the above

3. You connect the input of an inverting voltage amplifier to the collector of a transistor stage with a collector resistor of 2.7 kΩ. How much resistance would you need for the R_F resistor to get a gain of 10?
   A. 1.35 kΩ
   B. 270 Ω
   C. 270 kΩ
   D. 27 kΩ
   E. None of the above

4. A noninverting voltage amplifier with a gain of 100 uses a 741c op-amp with an open loop gain "A" of 100,000. What is the closed loop input impedance if the open loop input impedance is 2 kΩ?
   A. 100 MΩ
   B. 0.5 MΩ
   C. 2 MΩ
   D. 200 kΩ
   E. None of the above

5. What should the value of R_1 be in a noninverting voltage amplifier for a gain of 30 if R_2 is 1.2 kΩ?
   A. 34.8 kΩ
   B. 36 kΩ
   C. 28.8 kΩ
   D. 30 kΩ
   E. None of the above

6. What is the closed loop gain of a noninverting amplifier with R_1 equal to 82 kΩ and R_2 equal to 2.4 kΩ?
   A. 33
   B. 35
   C. 41
   D. 68
   E. None of the above

7. If a low-pass filter with a cutoff of 63 kHz is put in series with a high-pass filter with a cutoff of 57 kHz, what range of frequencies would this filter pass?
   A. 0 to 57 kHz
   B. 63 kHz and up
   C. From 57 to 63 kHz
   D. below 57 kHz and above 63 kHz
   E. None of the above

8. How fast will a 741c switch from 0 to 8 V?
   A. 40 µs
   B. 0.4 µs
   C. 4 µs
   D. 16 µs
   E. None of the above

9. If there are three open collector output circuits in parallel with a 1 kΩ pull-up resistor and 5 V feeding the 1 kΩ resistor, what voltage will be on the output if one of the output transistors is turned on and the other two are turned off?
   A. 0 V
   B. 5 V
   C. 2.5 V
   D. 1.7 V
   E. None of the above

10. What is the I.F. (intermediate frequency) in an AM receiver?
    A. 677.3 kHz
    B. 10.7 MHz
    C. 455 kHz
    D. 3.7 MHz
    E. None of the above

11. What is the first I.F. (intermediate frequency) in an FM radio receiver?
    A. 677.3 kHz
    B. 10.7 MHz
    C. 455 kHz
    D. 3.7 MHz

E. None of the above

12. What function does the grid have in a picture tube?
A. It shapes the electron beam.
B. It speeds up the electrons.
C. It keeps the electrons from returning to the filament.
D. It controls the amplitude of the electron beam.
E. None of the above

Section D: Digital Logic

PRETEST/POSTTEST

NAME Teacher's Key DATE

DIRECTIONS: Use scrap paper to make notes while working the problems. Pick the answer that appears to be the closest to the answer that you have calculated.

1. What is the binary number 101101_2 in hexadecimal?
   A. 13_{16}
   B. $2D_{16}$
   C. AF_{16}
   D. $D5_{16}$
   E. None of the above

2. What is a 4-bit binary number in 2s complement form for -3?
   A. 1110_2
   B. 0110_2
   C. 1101_2
   D. 0101_2
   E. None of the above

3. Convert the number 79_{10} to binary coded decimal.
   A. 111 1001
   B. 0100 0110
   C. 0111 1101
   D. 0111 1001
   E. None of the above

4. Where would pin 8 be on a 16-pin DIP if you are holding the chip with the notch at the top?
   A. Bottom right corner
   B. Top left corner
   C. Bottom left corner
   D. Top right corner
   E. None of the above

5. Which pins on a 16-pin DIP are used for V_{CC} and ground?
   A. V_{CC} is pin 16, and ground is pin 8.
   B. V_{CC} is pin 8, and ground is pin 16.
   C. V_{CC} is pin 16, and ground is pin 5.
   D. V_{CC} is pin 4, and ground is pin 12.
   E. None of the above

6. If it took 55 µs from the time a pulse arrived at the input until the output switched, what would we call the 55 µs?
   A. A long time

B. Bus line delay
C. Storage delay
D. Propagation delay
E. None of the above

7. In the 2s complement system, what indicates a negative number?
A. The computer uses a separate memory to store negative numbers.
B. The 1 is in the MSB position.
C. If the number is larger than the expected number, it will be negative.
D. A number below zero will be considered negative by the computer.
E. None of the above

8. What is the standard minimum voltage for a logic high in a TTL circuit?
A. 1.8 V
B. 2.0 V
C. 2.4 V
D. 2.8 V
E. None of the above

9. What voltage will noise have to exceed before it can cause a problem in TTL circuits?
A. 0.6 V
B. 0.2 V
C. 0.1 V
D. 0.4 V
E. None of the above

10. What is the maximum voltage for a logic low on a TTL circuit?
A. 0.4 V
B. 0.8 V
C. 1.0 V
D. 0.6 V
E. None of the above

11. What are the next four digits counting up from the hexadecimal number $F9F_{16}$?
A. F9G, F9H, F9I, F9J
B. F9A, FAB, FBC, FCD
C. FA0, FA1, FA2, FA3
D. FAF, FA1, FA2, FA3
E. None of the above

Unit E: Complex Digital Circuits

PRETEST/POSTTEST

NAME Teacher's Key DATE

DIRECTIONS: Use scrap paper to make notes while working the problems. Choose the answer that appears to be closest to the answer you have calculated.

1. What is the frequency of a signal coming from the Q output of the second FF? The input frequency to the first FF is 4 kHz, and the two FFs are connected together as a 2-bit ripple counter.
   A. 4 kHz
   B. 2 kHz
   C. 1 kHz
   D. 500 Hz
   E. None of the above

2. What logic is needed on the input to get a 1 on both the sum and carry-out of a single full adder?
   A. A should be 0, B should be 0, and C_{in} should be 1.
   B. A should be 0, B should be 1, and C_{in} should be 0.
   C. A should be 0, B should be 1, and C_{in} should be 1.
   D. A should be 1, B should be 1, and C_{in} should be 1.
   E. None of the above

3. What changes will you need to make in a ripple counter to make it count down instead of up?
   A. Connect the Q' outputs to the clock inputs.
   B. Turn the FFs around.
   C. Run the input through an inverter.
   D. Use a different type of FF.
   E. None of the above

4. How many FFs are needed for a MOD 11 counter?
   A. 6
   B. 4
   C. 2
   D. 1
   E. None of the above

5. How long does it take for a carry to ripple through a 64-bit adder when the propagation delay for the carry function in one full adder is 45 ns?
   A. 4.9 µs
   B. 1.3 µs
   C. 847 ns
   D. 2.9 µs
   E. None of the above

6. What will the output be for the BCD to decimal chip 7442, if the input is 1100?
   A. 9
   B. 12
   C. 3
   D. 7
   E. None of the above

7. If the inputs 2, 5, and 7 are active on a priority encoder, what binary number would be on the output?
   A. 0010_2
   B. 0101_2
   C. 0111_2
   D. 1000_2
   E. None of the above

8. What is the name of the circuit that allowed a computer to read the status of six remote stations, one at a time, in sequence?
   A. Demultiplexer
   B. Decoder
   C. Encoder
   D. Multiplexer
   E. None of the above

9. What approximately is the resistance when a transmission gate is turned on?
   A. 50 Ω
   B. 100 Ω
   C. 200 Ω
   D. 400 Ω
   E. None of the above

10. What is the name of the input that allows a decoder to work as a multiplexer?
    A. Clear input
    B. Enable input
    C. Set input
    D. Disable input
    E. None of the above

11. What is the maximum acceptable rise time for TTL circuits?
    A. 200 ns
    B. 100 ns
    C. 50 ns
    D. 25 ns
    E. None of the above

12. What is the name of the fast ADC circuit that does not count?
    A. Approximation ADC
    B. R.F. ADC
    C. Flash A/D
    D. Quick ADC
    E. None of the above

13. What voltages will the 7414 inverter with the Schmitt trigger input trigger on?
    A. 1.6 V and 0.8 V
    B. 2.8 V and 0.7 V
    C. 1.6 V and 0.4 V
    D. 1.2 V and 0.8 V
    E. None of the above

14. The following binary numbers are all BCD with odd parity. Which one is in error?
    A. 01000
    B. 10101
    C. 10100
    D. 10110
    E. None of the above

15. What should the impedance of the antenna coax be for a TV antenna?
    A. 100 Ω
    B. 75 Ω
    C. 50 Ω
    D. As little as possible
    E. None of the above

16. How many bits are in an ASCII word?
    A. 11 bits
    B. 8 bits
    C. 7 bits
    D. 4 bits
    E. None of the above

Unit F: Computer Circuits

PRETEST/POSTTEST

NAME Teacher's Key DATE

DIRECTIONS: Read each question carefully, and take your time. Use your notebook paper or scrap paper to solve the problems. Choose the answer that comes closest to the answer you have calculated.

1. How many address locations are in a memory unit of 8K X 32?
   A. 3,200
   B. 8,192
   C. 8,000
   D. 32
   E. None of the above

2. What is the word size in the memory unit in problem 1?
   A. 8
   B. 16
   C. 32
   D. 64
   E. None of the above

3. What is the name of the memory system that uses capacitors to store its data?
   A. RAM
   B. DRAM
   C. ROM
   D. EPROM
   E. None of the above

4. How big are the data bus and the address bus for the 6809 μP?
   A. 8 bits and 16 bits
   B. 6 bits and 8 bits
   C. 32 bits and 64 bits
   D. 16 bits and 32 bits
   E. None of the above

5. How big a memory can a μP with a 4-bit address bus access?
   A. 64 words
   B. 16 words
   C. 128 words
   D. 512 words
   E. None of the above

6. The new 68000 has a larger address bus than the 6800. How big is the 68000 address bus?
   A. 28 bits
   B. 24 bits

C. 32 bits
D. 12 bits
E. None of the above

7. What does *position independence* mean?
A. The independent position of address locations
B. Allowing the program counter to run free
C. A program which does not reference a specific address location
D. Lines of instruction in any position in the program
E. None of the above

8. What is a *flag* in the 6809 μP?
A. An error signal from control
B. A flag shows the condition of the μP.
C. The program is too fast.
D. Decoration in the programming chart
E. None of the above

9. What does the op-code *LDB* mean?
A. Load the B register contents into the A register.
B. Load the B register with the contents of the specified address location.
C. Sort the B and D registers.
D. Remove the B register contents, and store them in the specified address location.
E. None of the above

10. What does the documentation do?
A. It reduces errors in a program.
B. It will unlock a jammed program.
C. It guides the program.
D. It speeds up the program.
E. None of the above

11. In the 6809 μP, which bus is unidirectional?
A. Address bus
B. Data bus
C. Control bus
D. City bus
E. None of the above

12. What is the number of bits in a byte and in a nibble?
A. 16 and 6
B. 32 and 4
C. 8 and 4
D. 12 and 24
E. None of the above

Industrial Electronics II for ICT

FINAL EXAM

NAME Teacher's Key DATE

DIRECTIONS: Read each of the following questions carefully. There are no trick questions; however, students often have trouble with a question because they did not read it properly. Use scrap paper to work the mathematical parts of the problems. Choose the answer that is closest to the answer you have calculated.

1. What size of resistor should be added in series to limit the current to an LED in a 16 V circuit? Use the standard voltage drop and current requirement for an LED.
   A. 2.7 kΩ
   B. 470 Ω
   C. 910 Ω
   D. 180 Ω
   E. None of the above

2. What should the base emitter voltage be to forward-bias a diode?
   A. 1.2 V
   B. 0.2 V
   C. 0.7 V
   D. 6.8 V
   E. None of the above

3. With 18 V rms going into a filtered bridge rectifier circuit, what is the dc voltage on the output of this circuit?
   A. 16 V
   B. 18 V
   C. 36 V
   D. 24 V
   E. None of the above

4. A two-stage transistor amplifier has a gain of 80 in the first stage, a loss of 0.3 between stages, and a gain of 95 in the second stage. The loss between the second stage and the load is 0.5. What is the total gain in decibels?
   A. 20 dB
   B. 48 dB
   C. 30 dB
   D. 14 dB
   E. None of the above

5. If a differential amplifier with a gain of 200 has 1.6 V on V_1 and 1.59 V on V_2, what voltage is on the output? (Assume that the op-amp had zero volts on the output in the beginning.)
   A. 16 V
   B. 15.9 V
   C. 2 V
   D. 1.8 V

E. None of the above

6. What is the closed loop gain of a noninverting amplifier with R_1 equal to 80 kΩ and R_2 equal to 4.2 kΩ?
   A. 35
   B. 20
   C. 14
   D. 26
   E. None of the above

7. If four open collector output circuits are in parallel, and one of the output transistors is turned on and the other three are turned off, what is the approximate voltage on the output? The pull-up resistor has 5 V feeding it.
   A. 5 V
   B. 2.5 V
   C. 0 V
   D. 3.5 V
   E. None of the above

8. What is the number 12 in hexadecimal?
   A. 9_{16}
   B. A_{16}
   C. D_{16}
   D. C_{16}
   E. None of the above

9. Assume that you have connected two FFs together so that they are both toggling and the Q output of the first is connected to the clock input of the second. What is the frequency of the signal coming from the second FF's Q output if the period of the input signal is 10 ms?
   A. 45 Hz
   B. 25 Hz
   C. 50 Hz
   D. 12.5 Hz
   E. None of the above

10. How many address locations are in a memory unit with the capacity of 8K X 32?
    A. 8,000
    B. 256
    C. 32
    D. 8,192
    E. None of the above

Unit Tests and Final Exam

Unit A: Introduction and Review
PRETEST/POSTTEST

NAME _____ DATE _____

DIRECTIONS: Use some scrap paper when working out the problems. The answer that you derive may not be a perfect match with one of the choices. The difference can be a result of how you used your calculator or how many places you used in the calculations. If you are sure of your answer and one of the choices is close, then take it for your answer.

1. What is Ohm's law for finding voltage?
   A. V = I/R
   B. V = IR
   C. V = R/I
   D. V = E/RI
   E. None of the above

2. How much current will flow through a 2.7 kΩ resistor that is in parallel with a 12 V source?
   A. 3.7 mA
   B. 6.8 mA
   C. 18.5 mA
   D. 4.4 mA
   E. None of the above

3. What is the Thevenin equivalent circuit for figure 1?
   A. V_{Th} 13 V, R_{Th} 4.7 kΩ
   B. V_{Th} 16 V, R_{Th} 8.3 kΩ
   C. V_{Th} 11 V, R_{Th} 6.8 kΩ
   D. V_{Th} 10 V, R_{Th} 3.6 kΩ
   E. None of the above

4. What is the Norton equivalent circuit for figure 1?
   A. I_N 2.7 mA, R_{Th} 6.5 kΩ
   B. I_N 1.8 mA, R_{Th} 7.1 kΩ
   C. I_N 1.7 mA, R_{Th} 9.3 kΩ
   D. I_N 3.4 mA, R_{Th} 6.9 kΩ
   E. None of the above

5. What is the reactance of a 0.0047 μF capacitor in a circuit at 100 kHz?
   A. 280 Ω
   B. 339 Ω
   C. 520 Ω
   D. 470 Ω
   E. None of the above

6. What is the resonant frequency of a circuit with a 680 pF capacitor and 800 μH coil?
   A. 132 kHz
   B. 418 kHz
   C. 330 kHz
   D. 216 kHz
   E. None of the above

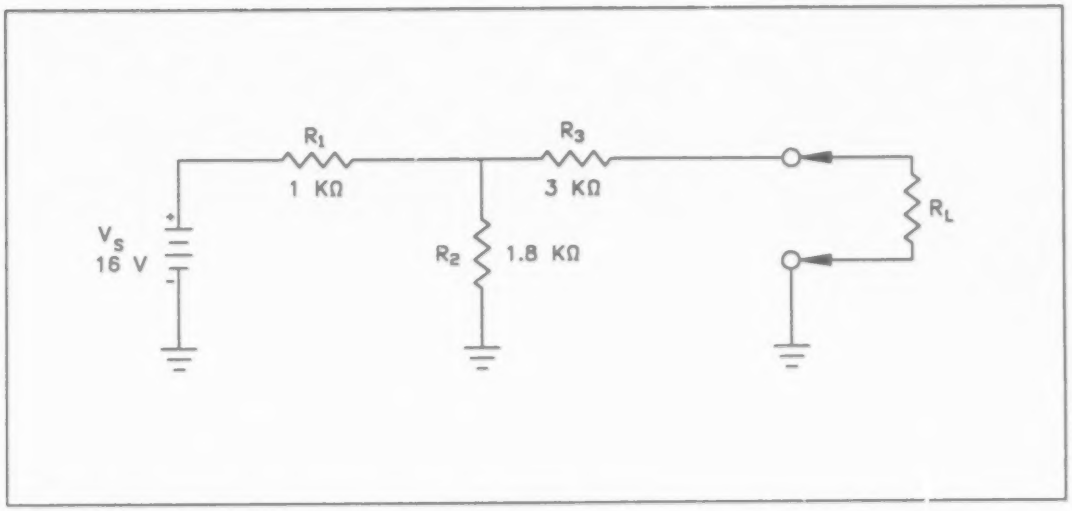

Figure 1

Unit B: Semiconductors
PRETEST/POSTTEST

NAME _____ DATE _____

DIRECTIONS: Use some scrap paper when working out the problems. The answer that you derive may not be a perfect match with one of the choices. The difference can be a result of how you used your calculator or how many places you used in the calculations. If you are sure of your answer and one of the choices is close, then take it for your answer.

1. What is the voltage at point A in figure 1?
   A. 27 V
   B. 24 V
   C. 21 V
   D. 18 V
   E. None of the above

2. What is the voltage at point C in figure 1?
   A. 9 V
   B. 11.3 V
   C. 9.6 V
   D. 10.3 V
   E. None of the above

3. In figure 1, what should the calculated value of the LED resistor R_2 be? Assume a load voltage of 14 V instead of the value you calculated in problem 2. (Calculated value only)
   A. 400 Ω
   B. 570 Ω
   C. 1.2 kΩ
   D. 800 Ω
   E. None of the above

4. In figure 1, what should the value of R_1 be, if the load requires 3 amperes, the beta of Q_1 is 25 and of Q_2 is 120, and the voltage at point A is 16 V? Use the calculated value for the resistance, not the adjusted value to include the additional current.
   A. 8.2 kΩ
   B. 5.7 kΩ
   C. 1.2 kΩ
   D. 12.7 Ω
   E. None of the above

5. In figure 1, calculate the voltage at point B. Use the values on the drawing.
   A. 10.3 V
   B. 11.7 V
   C. 9.6 V
   D. 11.0 V
   E. None of the above

6. A power transformer used in a linear power supply has a load of 8 Ω. The transformer is putting 12 V across the load. What is the primary current in the transformer?
   A. 348 mA
   B. 273 mA
   C. 235 mA
   D. 185 mA
   E. None of the above

7. In figure 2, if V_{CC} is 12 V, what is V_B on transistor Q_2?
   A. 1.97 V
   B. 2.35 V
   C. 2.86 V
   D. 1.27 V
   E. None of the above

8. In figure 2, if V_{CC} is 12 V, what is V_B on transistor Q_3?
   A. 10 V
   B. 8 V
   C. 4 V
   D. 6 V
   E. None of the above

9. In figure 2, if V_{CC} is 12 V, what is V_E on transistor Q_3?
   A. 5.3 V
   B. 6.7 V
   C. 8.2 V
   D. 8.9 V
   E. None of the above

10. Calculate the value of r_e' (ac emitter resistance) for transistor Q_2 in figure 2. (V_{CC} is 12 V.)
   A. 20.2 Ω
   B. 17 Ω
   C. 14.7 Ω
   D. 12.3 Ω
   E. None of the above

11. What is the voltage gain of transistor Q_2 in figure 2?
   A. 78.3
   B. 47.2

C. 31.5
D. 18.7
E. None of the above

12. What is the input impedance (Z_{in}) of transistor Q_2 in figure 2?
A. 470 Ω
B. 1 kΩ
C. 680 Ω
D. 802 Ω
E. None of the above

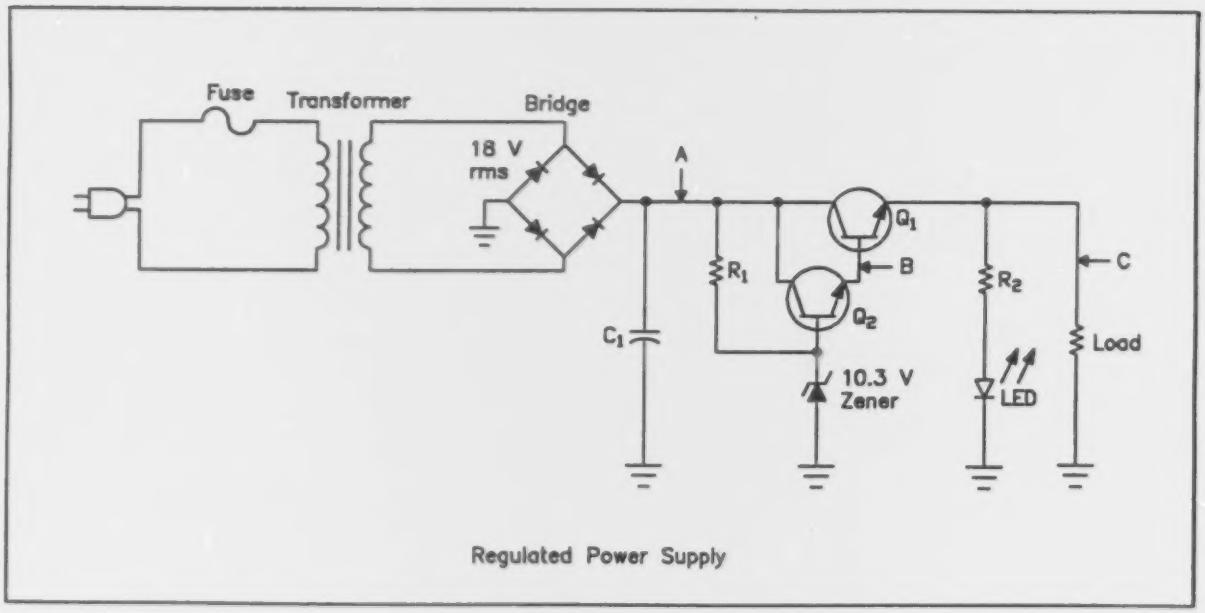

Figure 1

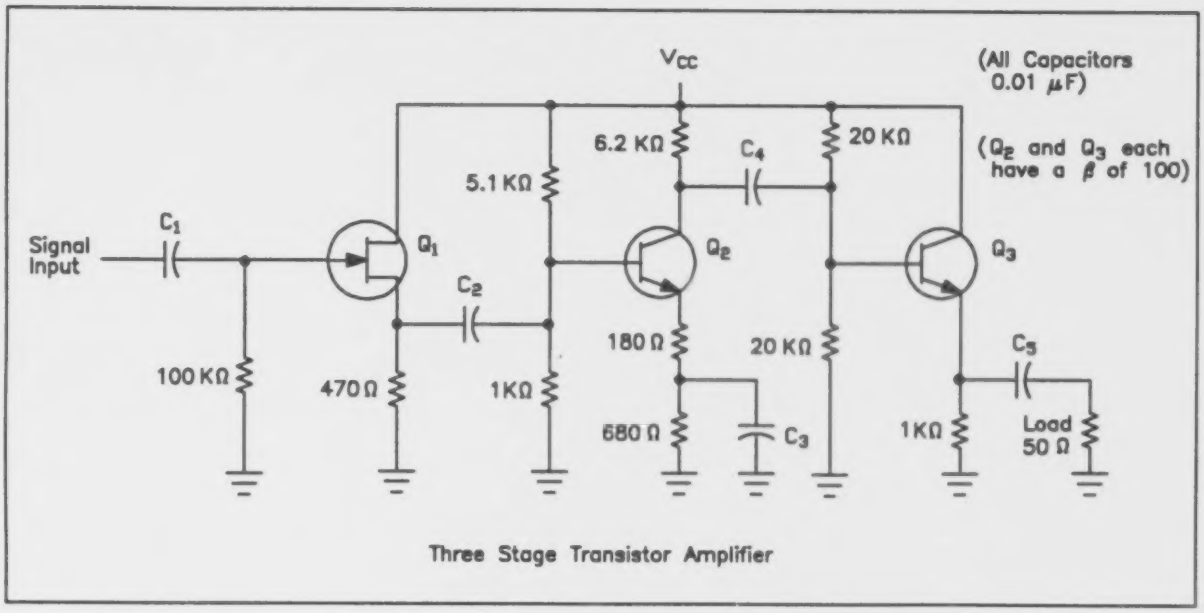
Vcc
(All Capacitors 0.01 μF)
(Q2 and Q3 each have a β of 100)
6.2 KΩ
C4
20 KΩ
5.1 KΩ
Signal Input
C1
Q1
Q2
Q3
C2
180 Ω
20 KΩ
C5
100 KΩ
470 Ω
1KΩ
680 Ω
C3
1KΩ
Load 50 Ω
Three Stage Transistor Amplifier

Figure 2

Unit C: Integrated Circuits
PRETEST/POSTTEST

NAME _____ DATE _____

DIRECTIONS: Use some scrap paper when working out the problems. The answer that you derive may not be a perfect match with one of the choices. The difference can be a result of how you used your calculator or how many places you used in the calculations. If you are sure of your answer and one of the choices is close, then take it for your answer.

1. A differential input of 2 mV gives 250 mV output, and the same 2 mV input as common mode gain gives 0.7 mV output. What is the common mode reject ratio?
   A. 489
   B. 357
   C. 275
   D. 146
   E. None of the above

2. If an op-amp amplifier with a gain of 150 has 1.3 V on V_1 and 1.29 V on V_2, what is on the output?
   A. 15 V
   B. 1.3 V
   C. 1.5 V
   D. 0.01 V
   E. None of the above

3. You connect the input of an inverting voltage amplifier to the collector of a transistor stage with a collector resistor of 2.7 kΩ. How much resistance would you need for the R_F resistor to get a gain of 10?
   A. 1.35 kΩ
   B. 270 Ω
   C. 270 kΩ
   D. 27 kΩ
   E. None of the above

4. A noninverting voltage amplifier with a gain of 100 uses a 741c op-amp with an open loop gain "A" of 100,000. What is the closed loop input impedance if the open loop input impedance is 2 kΩ?
   A. 100 MΩ
   B. 0.5 MΩ
   C. 2 MΩ
   D. 200 kΩ
   E. None of the above

5. What should the value of R_1 be in a noninverting voltage amplifier for a gain of 30 if R_2 is 1.2 kΩ?
   A. 34.8 kΩ
   B. 36 kΩ
   C. 28.8 kΩ
   D. 30 kΩ
   E. None of the above

6. What is the closed loop gain of a noninverting amplifier with R_1 equal to 82 kΩ and R_2 equal to 2.4 kΩ?
   A. 33
   B. 35
   C. 41
   D. 68
   E. None of the above

7. If a low-pass filter with a cutoff of 63 kHz is put in series with a high-pass filter with a cutoff of 57 kHz, what range of frequencies would this filter pass?
   A. 0 to 57 kHz
   B. 63 kHz and up
   C. From 57 to 63 kHz
   D. Below 57 kHz and above 63 kHz
   E. None of the above

8. How fast will a 741c switch from 0 to 8 V?
   A. 40 μs
   B. 0.4 μs
   C. 4 μs
   D. 16 μs
   E. None of the above

9. If there are three open collector output circuits in parallel with a 1 kΩ pull-up resistor and 5 V feeding the 1 kΩ resistor, what voltage will be on the output if one of the output transistors is turned on and the other two are turned off?
   A. 0 V
   B. 5 V
   C. 2.5 V
   D. 1.7 V
   E. None of the above

10. What is the I.F. (intermediate frequency) in an AM receiver?
   A. 677.3 kHz
   B. 10.7 MHz
   C. 455 kHz
   D. 3.7 MHz
   E. None of the above

11. What is the first I.F. (intermediate frequency) in an FM radio receiver?
   A. 677.3 kHz
   B. 10.7 MHz
   C. 455 kHz
   D. 3.7 MHz
   E. None of the above

12. What function does the grid have in a picture tube?
   A. It shapes the electron beam.
   B. It speeds up the electrons.
   C. It keeps the electrons from returning to the filament.
   D. It controls the amplitude of the electron beam.
   E. None of the above

Unit D: Digital Basics
PRETEST/POSTTEST

NAME _____ DATE _____

DIRECTIONS: Use scrap paper to make notes while working the problems. Pick the answer that appears to be the closest to the answer that you have calculated.

1. What is the binary number 101101_2 in hexadecimal?
   A. 13_{16}
   B. $2D_{16}$
   C. AF_{16}
   D. $D5_{16}$
   E. None of the above

2. What is a 4-bit binary number in 2s complement form for -3?
   A. 1110_2
   B. 0110_2
   C. 1101_2
   D. 0101_2
   E. None of the above

3. Convert the number 79_{10} to binary coded decimal.
   A. 111 1001
   B. 0100 0110
   C. 0111 1101
   D. 0111 1001
   E. None of the above

4. Where would pin 8 be on a 16-pin DIP if you are holding the chip with the notch at the top?
   A. Bottom right corner
   B. Top left corner
   C. Bottom left corner
   D. Top right corner
   E. None of the above

5. Which pins on a 16-pin DIP are used for V_{CC} and ground?
   A. V_{CC} is pin 16, and ground is pin 8
   B. V_{CC} is pin 8, and ground is pin 16
   C. V_{CC} is pin 16, and ground is pin 5
   D. V_{CC} is pin 4, and ground is pin 12
   E. None of the above

6. If it took 55 μs from the time a pulse arrived at the input until the output switched, what would we call the 55 μs?
   A. A long time
   B. Bus line delay
   C. Storage delay
   D. Propagation delay
   E. None of the above

7. In the 2s complement system, what indicates a negative number?
   A. The computer uses a separate memory to store negative numbers.
   B. The 1 is in the MSB position.
   C. If the number is larger than the expected number, it will be negative.
   D. A number below zero will be considered negative by the computer.
   E. None of the above

8. What is the standard minimum voltage for a logic high in a TTL circuit?
   A. 1.8 V
   B. 2.0 V
   C. 2.4 V
   D. 2.8 V
   E. None of the above

9. What voltage will noise have to exceed before it can cause a problem in TTL circuits?
   A. 0.6 V
   B. 0.2 V
   C. 0.1 V
   D. 0.4 V
   E. None of the above

10. What is the maximum voltage for a logic low on a TTL circuit?
    A. 0.4 V
    B. 0.8 V
    C. 1.0 V
    D. 0.6 V
    E. None of the above

11. What are the next four digits counting up from the hexadecimal number $F9F_{16}$?
    A. F9G, F9H, F9I, F9J
    B. F9A, FAB, FBC, FCD
    C. FA0, FA1, FA2, FA3
    D. FAF, FA1, FA2, FA3
    E. None of the above

Unit E: Complex Digital Circuits
PRETEST/POSTTEST

NAME _____ DATE _____

DIRECTIONS: Use scrap paper to make notes while working the problems. Choose the answer that appears to be closest to the answer you have calculated.

1. What is the frequency of a signal coming from the Q output of the second FF? The input frequency to the first FF is 4 kHz, and the two FFs are connected together as a 2-bit ripple counter.
   A. 4 kHz
   B. 2 kHz
   C. 1 kHz
   D. 500 Hz
   E. None of the above

2. What logic is needed on the input to get a 1 on both the sum and carry-out of a single full adder?
   A. A should be 0, B should be 0, and C_{in} should be 1.
   B. A should be 0, B should be 1, and C_{in} should be 0.
   C. A should be 0, B should be 1, and C_{in} should be 1.
   D. A should be 1, B should be 1, and C_{in} should be 1.
   E. None of the above

3. What changes will you need to make in a ripple counter to make it count down instead of up?
   A. Connect the Q' outputs to the clock inputs.
   B. Turn the FFs around.
   C. Run the input through an inverter.
   D. Use a different type of FF.
   E. None of the above

4. How many FFs are needed for a MOD 11 counter?
   A. 6
   B. 4
   C. 2
   D. 1
   E. None of the above

5. How long does it take for a carry to ripple through a 64-bit adder when the propagation delay for the carry function in one full adder is 45 ns?
   A. 4.9 μs
   B. 1.3 μs
   C. 847 ns
   D. 2.9 μs
   E. None of the above

6. What will the output be for the BCD to decimal chip 7442, if the input is 1100?
   A. 9
   B. 12
   C. 3
   D. 7
   E. None of the above

7. If the inputs 2, 5, and 7 are active on a priority encoder, what binary number would be on the output?
   A. 0010_2
   B. 0101_2
   C. 0111_2
   D. 1000_2
   E. None of the above

8. What is the name of the circuit that allowed a computer to read the status of six remote stations, one at a time, in sequence?
   A. Demultiplexer
   B. Decoder
   C. Encoder
   D. Multiplexer
   E. None of the above

9. What approximately is the resistance when a transmission gate is turned on?
   A. 50 Ω
   B. 100 Ω
   C. 200 Ω
   D. 400 Ω
   E. None of the above

10. What is the name of the input that allows a decoder to work as a multiplexer?
    A. Clear input
    B. Enable input
    C. Set input
    D. Disable input
    E. None of the above

11. What is the maximum acceptable rise time for TTL circuits?
    A. 200 ns
    B. 100 ns
    C. 50 ns
    D. 25 ns
    E. None of the above

12. What is the name of the fast ADC circuit that does not count?
    A. Approximation ADC
    B. R.F. ADC
    C. Flash A/D
    D. Quick ADC
    E. None of the above

13. What voltages will the 7414 inverter with the Schmitt trigger input trigger on?
    A. 1.6 V and 0.8 V
    B. 2.8 V and 0.7 V
    C. 1.6 V and 0.4 V
    D. 1.2 V and 0.8 V
    E. None of the above

14. The following binary numbers are all BCD with odd parity. Which one is in error?
    A. 01000
    B. 10101
    C. 10100
    D. 10110
    E. None of the above

15. What should the impedance of the antenna coax be for a TV antenna?
    A. 100 Ω
    B. 75 Ω
    C. 50 Ω
    D. As little as possible
    E. None of the above

16. How many bits are in an ASCII word?
    A. 11 bits
    B. 8 bits
    C. 7 bits
    D. 4 bits
    E. None of the above

Unit F: Computer Circuits
PRETEST/POSTTEST

NAME _____ DATE _____

DIRECTIONS: Read each question carefully, and take your time. Use your notebook paper or scrap paper to solve the problems. Choose the answer that comes closest to the answer you have calculated.

1. How many address locations are in a memory unit of 8K X 32?
   A. 3,200
   B. 8,192
   C. 8,000
   D. 32
   E. None of the above

2. What is the word size in the memory unit in problem 1?
   A. 8
   B. 16
   C. 32
   D. 64
   E. None of the above

3. What is the name of the memory system that uses capacitors to store its data?
   A. RAM
   B. DRAM
   C. ROM
   D. EPROM
   E. None of the above

4. How big are the data bus and the address bus for the 6809 μP?
   A. 8 bits and 16 bits
   B. 6 bits and 8 bits
   C. 32 bits and 64 bits
   D. 16 bits and 32 bits
   E. None of the above

5. How big a memory can a μP with a 4-bit address bus access?
   A. 64 words
   B. 16 words
   C. 128 words
   D. 512 words
   E. None of the above

6. The new 68000 has a larger address bus than the 6800. How big is the 68000 address bus?
   A. 28 bits
   B. 24 bits
   C. 32 bits
   D. 12 bits
   E. None of the above

7. What does *position independence* mean?
   A. The independent position of address locations
   B. Allowing the program counter to run free
   C. A program which does not reference a specific address location
   D. Lines of instruction in any position in the program
   E. None of the above

8. What is a *flag* in the 6809 μP?
   A. An error signal from control
   B. A flag shows the condition of the μP.
   C. The program is too fast.
   D. Decoration in the programming chart
   E. None of the above

9. What does the op-code *LDB* mean?
   A. Load the B register contents into the A register.
   B. Load the B register with the contents of the specified address location.
   C. Sort the B and D registers.
   D. Remove the B register contents, and store them in the specified address location.
   E. None of the above

10. What does the documentation do?
   A. It reduces errors in a program.
   B. It will unlock a jammed program.
   C. It guides the program.
   D. It speeds up the program.
   E. None of the above

11. In the 6809 μP, which bus is unidirectional?
   A. Address bus
   B. Data bus
   C. Control bus
   D. City bus
   E. None of the above

12. What is the number of bits in a byte and in a nibble?
   A. 16 and 6
   B. 32 and 4
   C. 8 and 4
   D. 12 and 24
   E. None of the above

Industrial Electronics II for ICT
FINAL EXAM

NAME_____ DATE_____

DIRECTIONS: Read each of the following questions carefully. There are no trick questions; however, students often have trouble with a question because they did not read it properly. Use scrap paper to work the mathematical parts of the problems. Choose the answer that is closest to the answer you have calculated.

1. What size of resistor should be added in series to limit the current to an LED in a 16 V circuit? Use the standard voltage drop and current requirement for an LED.
   A. 2.7 kΩ
   B. 470 Ω
   C. 910 Ω
   D. 180 Ω
   E. None of the above

2. What should the base emitter voltage be to forward-bias a diode?
   A. 1.2 V
   B. 0.2 V
   C. 0.7 V
   D. 6.8 V
   E. None of the above

3. With 18 V rms going into a filtered bridge rectifier circuit, what is the dc voltage on the output of this circuit?
   A. 16 V
   B. 18 V
   C. 36 V
   D. 24 V
   E. None of the above

4. A two-stage transistor amplifier has a gain of 80 in the first stage, a loss of 0.3 between stages, and a gain of 95 in the second stage. The loss between the second stage and the load is 0.5. What is the total gain in decibels?
   A. 20 dB
   B. 48 dB
   C. 30 dB
   D. 14 dB
   E. None of the above

5. If a differential amplifier with a gain of 200 has 1.6 V on V_1 and 1.59 V on V_2, what voltage is on the output? (Assume the op-amp had zero volts on the output in the beginning.)
   A. 16 V
   B. 15.9 V
   C. 2 V
   D. 1.8 V
   E. None of the above

6. What is the closed loop gain of a noninverting amplifier with R_1 equal to 80 kΩ and R_2 equal to 4.2 kΩ?
   A. 35
   B. 20
   C. 14
   D. 26
   E. None of the above

7. If four open collector output circuits are in parallel, and one of the output transistors is turned on and the other three are turned off, what is the approximate voltage on the output? The pull-up resistor has 5 V feeding it.
   A. 5 V
   B. 2.5 V
   C. 0 V
   D. 3.5 V
   E. None of the above

8. What is the number 12 in hexadecimal?
   A. 9_{16}
   B. A_{16}
   C. D_{16}
   D. C_{16}
   E. None of the above

9. Assume that you have connected two FFs together so that they are both toggling and the Q output of the first is connected to the clock input of the second. What is the frequency of the signal coming from the second FF's Q output if the period of the input signal is 10 ms?
   A. 45 Hz
   B. 25 Hz
   C. 50 Hz
   D. 12.5 Hz
   E. None of the above

10. How many address locations are in a memory unit with the capacity of 8K x 32?
    A. 8,000
    B. 256
    C. 32
    D. 8,192
    E. None of the above

CONTENTS OF STUDENT'S MANUAL

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- A-1: Review of DC and AC Circuits

Unit B. Semiconductors
- B-1: Diodes and Atomic Theory
- B-2: Rectifiers
- B-3: Filters and Zeners
- B-4: Diode Circuit LEDs
- B-5: Transistor Theory
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- B-7: Transistor Bias
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Unit E. Complex Digital Circuits
- E-1: Flip-Flops
- E-2: Registers I
- E-3: Binary Addition
- E-4: Decoders
- E-5: Encoders and Multiplexers
- E-6: One Shot and Schmitt Triggers
- E-7: Interface with the Linear World
- E-8: Data Transmission

Unit F. Computer Circuits
- F-1: Memory Devices
- F-2: Microprocessor Theory
- F-3: Computer Language

WORK SHEET

FOR COORDINATING JOBS WITH RELATED INSTRUCTION USING

INDUSTRIAL ELECTRONICS II FOR ICT

This form is for your convenience in planning and keeping records of training. Contents of the student's manual are at the left. The columns below provide space for listing job experiences for the individual student and assignment numbers and other references related to each job. Blanks are large and divided by days so the teacher and student can list other information that might be useful in a weekly log.

Student _____

Training Station _____

JOB EXPERIENCES	RELATED INSTRUCTION
Monday Work Hrs:	
Tuesday Work Hrs:	
Wednesday Work Hrs:	
Thursday Work Hrs:	
Friday Work Hrs:	

COMPLIANCE STATEMENT

TITLE VI, CIVIL RIGHTS ACT OF 1964; THE MODIFIED COURT ORDER, CIVIL ACTION 5281, FEDERAL DISTRICT COURT, EASTERN DISTRICT OF TEXAS, TYLER DIVISION

Reviews of local education agencies pertaining to compliance with Title VI Civil Rights Act of 1964 and with specific requirements of the Modified Court Order, Civil Action No. 5281, Federal District Court, Eastern District of Texas, Tyler Division are conducted periodically by staff representatives of the Texas Education Agency. These reviews cover at least the following policies and practices:

(1) acceptance policies on student transfers from other school districts;

(2) operation of school bus routes or runs on a non-segregated basis;

(3) nondiscrimination in extracurricular activities and the use of school facilities;

(4) nondiscriminatory practices in the hiring, assigning, promoting, paying, demoting, reassigning, or dismissing of faculty and staff members who work with children;

(5) enrollment and assignment of students without discrimination on the basis of race, color, or national origin;

(6) nondiscriminatory practices relating to the use of a student's first language; and

(7) evidence of published procedures for hearing complaints and grievances.

In addition to conducting reviews, the Texas Education Agency staff representatives check complaints of discrimination made by a citizen or citizens residing in a school district where it is alleged discriminatory practices have occurred or are occurring.

Where a violation of Title VI of the Civil Rights Act is found, the findings are reported to the Office for Civil Rights, Department of Health, Education and Welfare.

If there is a direct violation of the Court Order in Civil Action No. 5281 that cannot be cleared through negotiation, the sanctions required by the Court Order are applied.

TITLE VII, CIVIL RIGHTS ACT OF 1964; EXECUTIVE ORDERS 11246 and 11375; TITLE IX 1973 EDUCATION AMENDMENTS; REHABILITATION ACT OF 1973 AS AMENDED; 1974 AMENDMENTS TO THE WAGE-HOUR LAW EXPANDING THE AGE DISCRIMINATION IN EMPLOYMENT ACT OF 1967; VIETNAM ERA VETERANS READJUSTMENT ASSISTANCE ACT OF 1972 AS AMENDED IN 1974.

It is the policy of the Texas Education Agency to comply fully with the nondiscrimination provisions of all federal and state laws and regulation by assuring that no person shall be excluded from consideration for recruitment, selection, appointment, training, promotion, retention, or any other personnel action, or be denied any benefits or participation in any programs of activities which it operates on the grounds of race, religion, color, national origin, sex, handicap, age, or veteran status (except where age, sex, or handicap constitute a bona fide occupational qualification necessary to proper and efficient administration). The Texas Education Agency makes positive efforts to employ and advance in employment all protected groups.

CURRICULUM GUIDE

FOR

INDUSTRIAL ELECTRONICS II for ICT

By

Troy Notgrass

Published by

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How to Use the Curriculum Guide for Industrial Electronics II for ICT

Industrial Electronics II for ICT is an occupationally specific course for students in grade 12. It is designed as a one-hour, one-year (180 classroom hours—2 credits) course with appropriate training at an approved cooperative training station. Industrial Electronics II for ICT is a second-year course which will provide students with job entry-level skills as well as prepare them with the background necessary to study industrial electronics at the college level.

Organizational Design

Material in this guide may be used in either of two ways. First, it may be used to help the instructor develop a study guide for the student. In this instance, the student's manual could serve as the text. Other useful information for the instructor is the list of essential elements common to all trade and industrial courses, essential elements for industrial electronics courses, and assignment titles with objectives and essential elements covered in that assignment.

Second, these prepared student's manuals and instructor's guides may be purchased from:

The University of Texas at Austin
Extension Instruction and Materials Center
P.O. Box 7218
Austin, TX 78713-7218

The instructor's guide is designed to help the instructor make certain that each student gets the most benefit possible out of both the student's manual and what is learned at the training station. It provides answers to exercises and unit test questions, the unit tests, and a work sheet to help in coordinating work experiences with the assignments.

The instructor should keep all answers to questions. The actual unit tests can be removed to make them easier to use or reproduce. For greater convenience, the instructor's guide is punched for notebook use and held together by staples only.

The student's self-contained manual is designed for use in presenting related technical information to (1) groups of trade and industrial students with a variety of vocational objectives and (2) homogeneous groups in which the learning levels of individuals vary considerably. The manual is not intended to be used as a type of correspondence course, but must be used by students under the direct supervision of an instructor.

Academic Background Recommended

The student must have the correct background in order to succeed in this field.

English. The student should have a good background in English and read at the eleventh-grade level in order to read and understand the schematics, specifications, etc.

Mathematics. The student should have a good background in math. Successful completion of one year of algebra is essential.

Science. Background courses in physics and chemistry are beneficial to the electronics student.

Aptitudes. The student should have an aptitude for logic and a high degree of manual dexterity.

This information may be used in counseling students who express a desire to train in this field. It also could be useful to school counselors who may have the opportunity to guide students toward a vocational program.

Content Development

Industrial Electronics II for ICT is designed as a self-study text which does not rely upon a knowledgeable instructor and requires no laboratory. For this reason, the emphasis is more on the fundamentals of electronics than on mathematics. The student's manual covers all the passive devices and the theory to support them. Students will progress from the fundamentals of electricity through an overview of digital electronics. Each assignment will build on the knowledge students have gained from the previous assignments. Each assignment will be more complex than previous ones; therefore, students should study the assignments in sequence. When they have completed this course, they will be adequately prepared to enroll in industrial electronics at the college level or continue working in the industrial electronics field.

Organization

The student's manual is designed to use as many fundamental teaching principles as possible. Each part of the manual is based on one of these principles.

Objectives. The first fundamental teaching principle is that the student should be *informed* at the outset the objectives to be learned in the assignment. These are performance objectives that can be tested on completion of the assignment.

Technical information. The second teaching principle is that technical information should be presented in *complete, but concise form.* This information is presented step-by-step, proceeding from the simple to the complex, from the known to the unknown. Of the four teaching principles discussed here, this is by far the most important.

Exercise. The third teaching principle is that technical information is better learned it if can be *applied* as soon as possible after presentation. This is done through exercise questions for each assignment. The questions are phrased to emphasize key points, to aid in learning facts that must be memorized, or to provoke thought about evaluation of the technical information. You should emphasize to students that both the objectives and the technical information should be read before any attempt is made to answer questions in the exercise. Answers may also be useful when helping a student who is having difficulty with an assignment exercise. Students' answers need not be stated in exactly the same words used in the assignment information.

Tests. A fourth teaching principle is carried out in the instructor's guide. This principle is that the effectiveness of the assignment should be *evaluated*. Evaluation is effected through a unit test that is keyed to the objectives stated for the assignments. These tests should be given on completion of the unit. Answers to tests provide a reference for grading. *You should retain all answers.*

Tests and Work Sheet

The last section of the instructor's guide has been placed after a divider page so that the tests and the work sheet can be removed for use with individual students or for reproduction. You may reproduce these pages *without permission.*

The work sheet is provided for your convenience in (1) planning how job experience is to be matched to related instruction in the student's manual and (2) keeping daily records as the student progresses through the year. The assignments are coded and can be easily listed opposite the desired jobs. Also, space is provided for other records you may wish to include on the work sheet.

If the suggested curriculum materials listed are used, the essential element requirements will be met.

Instructional Delivery Outline

Assignment No.	Title	Essential Elements
A.	Introduction and Review	
A-1	Review of DC and AC Circuits	(o)(1,2,3,8,9,10,16)
B.	Semiconductors	
B-1	Diodes and Atomic Theory	(o)(5)
B-2	Rectifiers	(o)(4,5,9,11,15)
B-3	Filters and Zeners	(o)(4,6,7,9,11,15)
B-4	Diode Circuit LEDs	(o)(4,5,9,11)
B-5	Transistor Theory	(o)(5,11,15,16)
B-6	Transistor Switch	(o)(5,9,11,12,16)
B-7	Transistor Bias	(o)(5,6,9,11,12,16)
B-8	Transistor Amplifier	(o)(5,6,9,11,12,16)
B-9	Multistage Transistor Amplifiers	(o)(5,6,9,11,12,16)
B-10	Oscillators and Feedback	(o)(5,6,9,11,12,16)
B-11	Voltage Regulation	(o)(5,6,9,11,12,16)
B-12	Other Types of Transistors	(o)(5,6,9,11,12,16)
B-13	Thyristors	(o)(5,6,9,11,12,16)
C.	Integrated Circuits	
C-1	Op-Amp Theory	(o)(5,6,12,15,16)
C-2	Op-Amp Amplifiers I	(o)(5,6,12,15,16)
C-3	Op-Amp Amplifiers II	(o)(5,6,12,15,16)
C-4	Op-Amp Amplifiers III	(o)(5,6,12,15,16)
C-5	Nonlinear Op-Amp Circuits	(o)(5,6,15,16)
C-6	555 Integrated Circuit	(o)(5,6,9,11,15,16)
C-7	AM and FM Modulation	(o)(9,15,16)
C-8	Video Monitoring Systems	(o)(1,5,6,8,9,11,16)
D.	Digital Basics	
D-1	Introduction to Digital	(o)(4,15)
D-2	Binary, Hex, and Decimal Systems	(o)(13,16)
D-3	Logic Gates and Diagrams	(o)(13,16)
D-4	Boolean Algebra	(o)(13,16)
D-5	XOR and XNOR	(o)(13,16)
E.	Complex Digital Circuits	
E-1	Flip-Flops	(o)(13,16)
E-2	Registers I	(o)(13,14,15,16)
E-3	Binary Addition	(o)(13,14,15,16)
E-4	Decoders	(o)(13,14,15,16)
E-5	Encoders and Multiplexers	(o)(13,14,15,16)
E-6	One Shot and Schmitt Triggers	(o)(13,14,15,16)
E-7	Interface with the Linear World	(o)(13,14,15,16)
E-8	Data Transmission	

F. Computer Circuits

F-1	Memory Devices	(o)(13,14,15,16)
F-2	Microprocessor Theory	(o)(13,14,15,16)
F-3	Computer Language	(o)(13,14,15)

Essential Elements Common to All Trade and Industrial Courses

§75.88 Trade and Industrial Education

(a) The elements in this subsection are **common to all trade and industrial courses** unless otherwise indicated and shall be included in each course at the appropriate level. They are described here to preclude repetition in each course. Every school offering trade and industrial education shall provide courses which include the following essential elements:

(1) *Leadership* concepts and skills. The student shall be provided opportunities to:

(A) demonstrate skills, characteristics, and responsibilities of leaders and effective group members;
(B) demonstrate a knowledge of parliamentary procedure principles;
(C) plan and conduct leadership activities; and
(D) prepare for effective citizenship and for participation in our democratic society.

(2) Concepts and skills related to successful *employment* and/or *postsecondary training*. The student shall be provided opportunities to:

(A) identify employment opportunities and preparation requirements in chosen fields;
(B) identify effective methods to secure and terminate employment;
(C) demonstrate effective communication skills both oral and written and follow through on assigned tasks;
(D) demonstrate dependability and punctuality;
(E) demonstrate productive work habits and attitudes;
(F) understand the importance of taking pride in the quality of work performed;
(G) recognize the dignity in work;
(H) develop skills in planning and organizing work;
(I) apply required methods and sequences when performing tasks;
(J) apply principles of time management and work simplification when performing assigned tasks;
(K) identify ethical practices and responsibilities; and
(L) understand the importance of the application of organizational policies and procedures.

(3) Concepts and skills associated with *entrepreneurship*. The student shall be provided opportunities to:

(A) identify opportunities for business ownership;
(B) understand the risk and profit motive factor;
(C) understand the elements and advantages of the free enterprise system; and
(D) explain the role of small business in the free enterprise system.

(4) Concepts and skills related to *safety and safe working conditions*. The student shall be provided opportunities to identify and apply safe working practices to all training situations.

(5) Concepts and skills associated with *human relations and personality development*. The student shall be provided opportunities to:

(A) understand the importance of maintaining good health and proper appearance for effective job performance;
(B) understand oneself and others;
(C) exercise self-control;
(D) accept and use criticism;
(E) recognize basic human relationships as they relate to business success; and
(F) demonstrate characteristics for successful working relationships.

(6) Concepts and skills related to *personal and business management*. The student shall be provided opportunities to:

(A) explain how management assists in reaching personal and family goals;
(B) explain the management process;
(C) describe the role of management in controlling stress;
(D) identify and understand personal checking accounts;
(E) identify and understand personal loan application process;
(F) identify and understand different financial institutions;
(G) identify the role and function of business management;
(H) understand the lines of authority; and
(I) identify effective supervisory techniques.

(7) Concepts and skills associated with the *specific occupation* being taught. The student shall be provided opportunities to:

(A) understand the basic concepts of and develop proficiency in the occupational area for which instruction/training is provided;
(B) develop a fundamental understanding of mathematical principles and scientific procedures;
(C) understand terminology utilized;
(D) identify tools, equipment, and materials used; and
(E) develop and demonstrate appropriate techniques for the selection, use, maintenance, and storage of tools, equipment, and materials.

Essential Elements for Industrial Electronics

(o) Concepts and skills associated with *industrial electronics*. The student shall be provided opportunities to:

(1) apply Ohm's law and power theory;
(2) investigate direct current circuit analysis;
(3) understand magnetism as it relates to electronic circuits;
(4) design and build electronic circuits utilizing schematic diagrams;
(5) understand the structure, theory, and operation of semiconductors and integrated circuits;
(6) apply a method of testing semiconductor devices using *appropriate* test equipment;
(7) investigate voltage regulation devices;
(8) understand the relationship of voltage, current, resistance, and reactance in alternating current circuits;
(9) understand electronic theory and application as it applies to generators, electric motors, power supplies, electronic amplifiers, electronic oscillators, communication circuits, and communication systems;
(10) investigate AC circuit analysis;
(11) analyze malfunctions in electronic circuitry;
(12) understand the operation of basic transistor circuits and operational amplifiers in linear circuits;
(13) analyze digital electronic circuits;
(14) investigate microprocessor applications;
(15) become aware of state of the art technology; and
(16) apply the proper procedures for the use of electronic test equipment.

Assignment Titles, Objectives, and Related Essential Elements

Unit A.	**Introduction and Review**
UNIT OBJECTIVE:	Upon completion of this instructional unit, the student will be able to demonstrate a residual knowledge of Industrial Electronics I studied last year.
A-1	Review of DC and AC Circuits
Essential Elements	(o) (1,2,3,8,9,10,16)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. dc and ac electronic theory studied last year; and 2. reactance, impedance, and resonance studied last year.
Unit B.	**Semiconductors**
UNIT OBJECTIVE:	Upon completion of this instructional unit, the student(s) will be able to demonstrate a knowledge of how semiconductor devices operate and how they are used in a circuit.
B-1	Diodes and Atomic Theory
Essential Elements	(o)(5)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. basic atomic theory; and 2. the basic internal structure of a diode and transistor.
B-2	Rectifiers
Essential Elements	(o)(4,5,9,11,15)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. rectifier circuits; and 2. basic power supply design.
B-3	Filters and Zeners
Essential Elements	(o)(4,6,7,9,11,15)

SPECIFIC OBJECTIVES: Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of—
1. capacitor filter circuits; and
2. zener circuits.

B-4 Diode Circuit LEDs

Essential Elements (o)(4,5,9,11)

SPECIFIC OBJECTIVES: Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of—
1. voltage multipliers; and
2. light-emitting diodes.

B-5 Transistor Theory

Essential Elements (o)(5,11,15,16)

SPECIFIC OBJECTIVES: Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of—
1. how a transistor works; and
2. how to test a transistor.

B-6 Transistor Switch

Essential Elements (o)(5,9,11,12,16)

SPECIFIC OBJECTIVES: Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of—
1. how transistor switching works; and
2. how to design a simple transistor switch.

B-7 Transistor Bias

Essential Elements (o)(5,6,9,11,12,16)

SPECIFIC OBJECTIVES: Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of—
1. how to bias a transistor circuit; and
2. how to design simple linear transistor circuits.

B-8 Transistor Amplifier

Essential Elements (o)(5,6,9,11,12,16)

SPECIFIC OBJECTIVES: Upon completion of this assignment, the student(s) will be able to calculate—
1. the voltage gain of a simple transistor circuit; and
2. the impedance of a simple transistor circuit.

B-9	Multistage Transistor Amplifiers
Essential Elements	(o)(5,6,9,11,12,16)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. how to calculate the voltage gain of a multiple-stage transistor circuit; 2. how to calculate the impedance losses in multiple-stage circuits; and 3. the class A, B, and C transistor circuits.
B-10	Oscillators and Feedback
Essential Elements	(o)(5,6,9,11,12,16)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. oscillation; and 2. crystal-controlled oscillators.
B-11	Voltage Regulation
Essential Elements	(o)(5,6,9,11,12,16)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. voltage regulation; 2. current control; and 3. the use of integrated circuits for voltage and current control.
B-12	Other Types of Transistors
Essential Elements	(o)(5,6,9,11,12,16)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. JFET transistors; and 2. MOSFET transistors.
B-13	Thyristors
Essential Elements	(o)(5,6,9,11,12,16)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. the family of SCR devices; and 2. how to troubleshoot SCR-type devices.

UNIT C.	**Integrated Circuits**
UNIT OBJECTIVE:	Upon completion of this instructional unit, the student will be able demonstrate a knowledge of integrated circuits and the op-amp circuit.
C-1	Op-Amp Theory
Essential Elements	(o)(5,6,12,15,16)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. the basic theory of the 741 op-amp; and 2. the construction of an op-amp.
C-2	Op-Amp Amplifiers I
Essential Elements	(o)(5,6,12,15,16)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. negative feedback circuitry on the op-amp; and 2. how negative feedback affects the circuit parameters.
C-3	Op-Amp Amplifiers II
Essential Elements	(o)(5,6,12,15,16)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. using a single supply with op-amp circuitry; and 2. adding additional circuitry inside the feedback loop.
C-4	Op-Amp Amplifiers III
Essential Elements	(o)(5,6,12,15,16)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. other important op-amp circuits; and 2. how to troubleshoot unfamiliar op-amp circuits.
C-5	Nonlinear Op-Amp Circuits
Essential Elements	(o)(5,6,15,16)

SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. comparators and Schmitt triggers; and 2. how the nonlinear comparator and Schmitt trigger circuits work.
C-6	555 Integrated Circuit
Essential Elements	(o)(5,6,9,11,15,16)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. how the 555 timer integrated circuit operates; and 2. how to use and troubleshoot circuits using 555 timer chips.
C-7	AM and FM Modulation
Essential Elements	(o)(9,15,16)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. the effect of mixing frequencies; and 2. AM and FM modulation.
C-8	Video Monitoring Systems
Essential Elements	(o)(1,5,6,8,9,11,16)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. video transmitting systems; and 2. video receiving systems.
UNIT D.	**Digital Basics**
UNIT OBJECTIVE:	Upon completion of this instructional unit, the student will be able to demonstrate a knowledge of numbering systems with different bases, work with logic gates, understand logic diagrams, and be familiar with Boolean algebra.
D-1	Introduction to Digital
Essential Elements	(o)(4,15)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. the relationship between processing and memory circuits; and 2. the different troubleshooting methods used in digital circuits.

D-2	Binary, Hex, and Decimal Systems
Essential Elements	(o)(13,16)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. how to count, add, and subtract using binary numbers; 2. other numbering systems; and 3. how to work with other numbering systems.
D-3	Logic Gates and Diagrams
Essential Elements	(o)(13,16)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. logic symbols; 2. reading and drawing logic gates; and 3. waveforms and logic gates.
D-4	Boolean Algebra
Essential Elements	(o)(13,16)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. how to simplify Boolean algebraic expressions; and 2. how to draw logic diagrams for Boolean expressions.
D-5	XOR and XNOR
Essential Elements	(o)(13,16)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. the XOR and XNOR gates; and 2. the difference between TTL outputs and tristate.
UNIT E.	**Complex Digital Circuits**
UNIT OBJECTIVE:	Upon completion of this instructional unit, the student will be able to demonstrate a knowledge of registers and adders, and of circuits that convert analog to digital and transmit data.
E-1	Flip-Flops
Essential Elements	(o)(13,16)

SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. how a flip-flop is made; and 2. how a flip-flop works.
E-2	Registers I
Essential Elements	(o)(13,14,15,16)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. series and parallel input and output of data to a register; and 2. the ripple counter and MOD numbers.
E-3	Binary Addition
Essential Elements	(o)(13,14,15,16)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. how a single full adder can add binary numbers; and 2. the full system for adding and subtracting binary numbers.
E-4	Decoders
Essential Elements	(o)(13,14,15,16)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. how a decoder works; and 2. LED and LCD display systems.
E-5	Encoders and Multiplexers
Essential Elements	(o)(13,14,15,16)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. how an encoder works; 2. how a multiplexer works; and 3. how a demultiplexer works.
E-6	One Shot and Schmitt Triggers
Essential Elements	(o)(13,14,15,16)

SPECIFIC OBJECTIVES:

Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of—
1. how a Schmitt trigger works;
2. how a one shot works; and
3. the CMOS transmission gate.

E-7 Interface with the Linear World

Essential Elements (o)(13,14,15,16)

SPECIFIC OBJECTIVES:

Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of—
1. how a digital analog convertor works;
2. how an analog digital convertor works; and
3. the flash analog digital convertor.

E-8 Data Transmission

SPECIFIC OBJECTIVES:

Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of—
1. the parity systems; and
2. fiber optics.

UNIT F. Computer Circuits

UNIT OBJECTIVE:

Upon completion of this instructional unit, the student will be able to demonstrate a knowledge of the concepts of the memory section of a computer, and the μP structure and simple programming.

F-1 Memory Devices

Essential Elements (o)(13,14,15,16)

SPECIFIC OBJECTIVES:

Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of—
1. how a memory system is organized and addressed; and
2. how data moves in and out of a memory system.

F-2 Microprocessor Theory

Essential Elements (o)(13,14,15,16)

SPECIFIC OBJECTIVES:

Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of—
1. how a microprocessor is organized; and
2. how the microprocessor can address and move data.

F-3	Computer Language
Essential Elements	(o)(13,14,15)
SPECIFIC OBJECTIVES:	Upon completion of this assignment, the student(s) will be able to demonstrate a knowledge of— 1. how a program will control a computer; and 2. how a program can be written.

References

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